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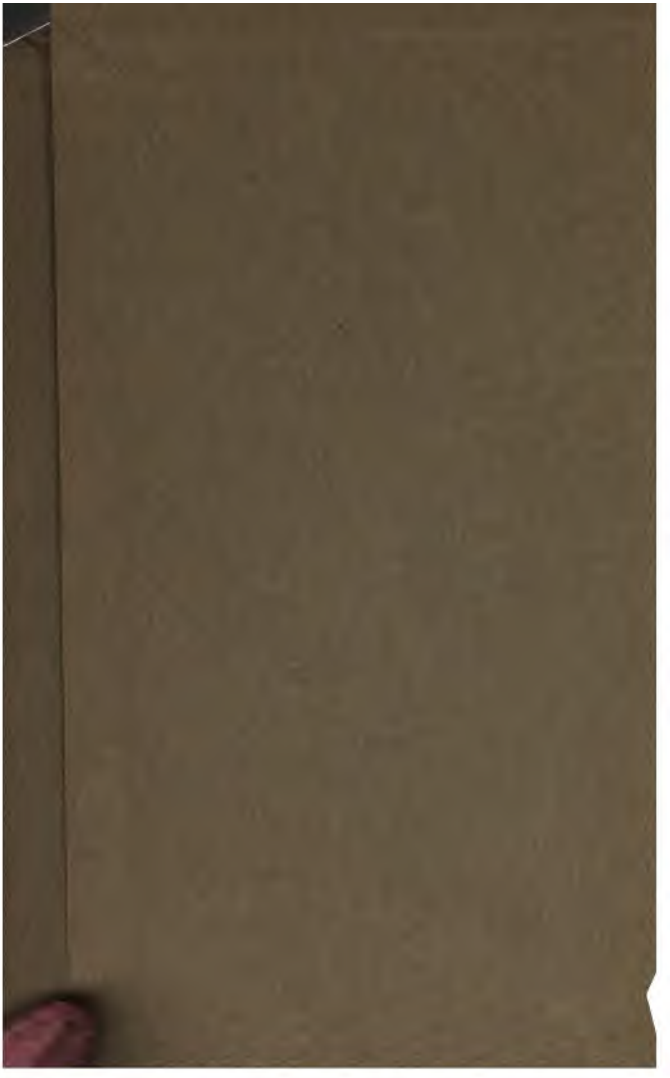

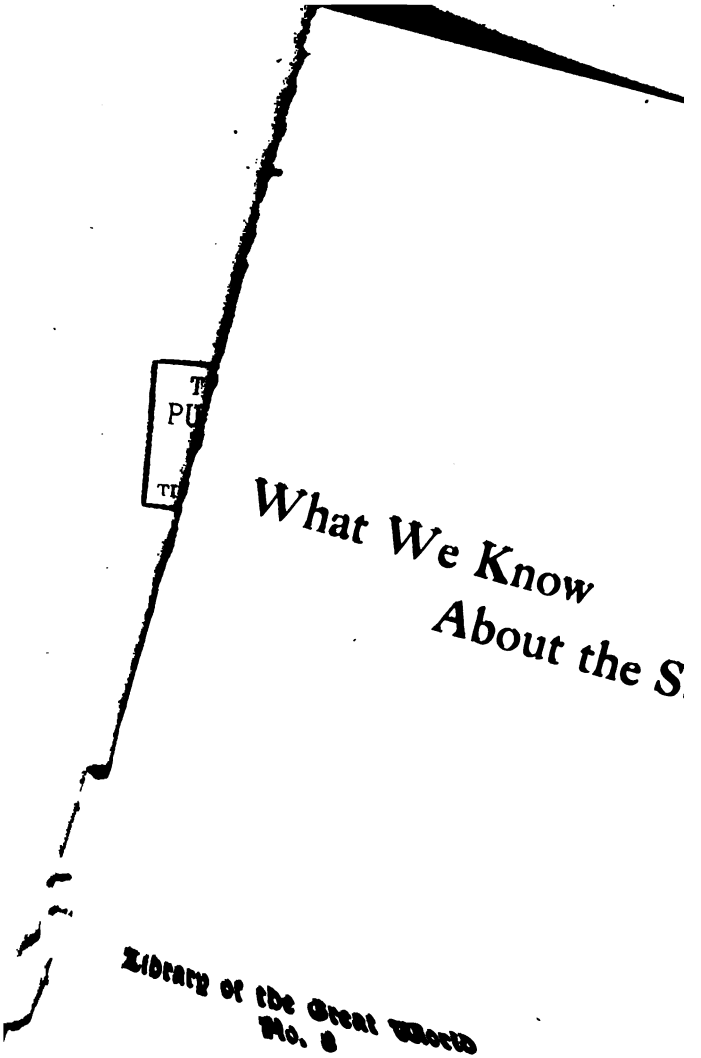

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Published Oct. 1, 1905

"Look how the floor of heaven
Is thick inlaid with patines of bright gold:
There's not the smallest orb which Thou behold'st
But in his motion like an angel sings,
Still quiring to the young-eyed cherubims."
—SHAKESPEARE'S "Merchant of Venice."

What We Know About the Stars

CHAPTER I

The Universe

Foreword.—The majority of people, who toil through the day and watch with eagerness for a night of rest, are wholly unconscious of the pleasure those have who, night after night, through most of the hours till dawn, watch "the far, still stars" in their heavenly courses, and to whom astronomy is the sublimest science known to intelligent beings. The many do not realize, but the few know, that it reaches farther and touches more wonders than any other physical science; that its finger-boards point the way over—

"A broad and ample road, whose dust is gold,
And pavement stars."

As a science, astronomy is as old as the human

race. It is said that Adam was the first astronomer; how could he help being one? It is certain there could not have been a time when men did not look up at the heavens at night and wonder at the twinkling orbs, conjure forms of constellations and express surprise at comets, meteors and eclipses of the moon and sun. Nor will there ever be a time on this planet[1] when Nature's laws regulating the Visible Universe will not be the occasion for great searching and profound thought.

There is no reason why we—everyone of us—should not be close "observers." Astronomers we may not be, but observers we can be. Every clear night, before lying down to rest, we may take a brief walk, say of fifteen minutes at least, and observe the stately march of a host of beautiful suns, stretching far along the highways of infinity, whose number runs into the millions, whose sizes and swiftnesses of motion are as wonderful and as diverse as their number, whose colors are as varied as those of the rainbow, and whose actual condition, solid or gaseous, can only be judged by what we have learned of our own great solar orb; and at the same time we may take note of the constellations, the brighter and less bright stars, and the numberless curious phenomena that will gradually develop before our eyes. In time, the skies will become as familiar to us as our own street or town. Even such a "naked eye" observation will give zest for sleep and fill the mind with unutterable thoughts. It is inspiring, beyond the power of language, to look out after nightfall *into immensity* and view the myriad golden pearls

that make up the sparkling coronet of jewels of the Visible Universe.

But every intelligent person should do more than merely spy out what his own eyes will see. He should have some real knowledge of "what we know about the stars,"—their distances, movements, variableness, inter-relations; their probable origin, progress as stars, possible destiny. The subject popularly treated is not so difficult of understanding in many of its branches, and is by no means fanciful. Astronomy is a real thing; a genuine manifestation of the manifold glories of past ages; a presage of new evolutions in the future; a rescript of the visible thought and mind of God. It is another open book of Revelation, and, like the Bible itself, is both milk for the babe and meat for the strong.

Of course we do not mean to say that astronomy is so exact a science that all its problems are as demonstrable as a problem in Euclid. There are mere guesses connected with it, but these only surround its truths with a halo of romance. So far as real problems are solved it is an exact science. That the astronomers are enabled to calculate, hundreds of years in advance, the precise moment of the transit of Venus across the Sun, or of an eclipse of the sun or moon, or when a certain comet is due to appear, only proves that facts have been acquired which are exact, and that the machinery of the heavens does not run on by chance but under fixed laws.

Astronomy also has problems the most profound and the most difficult with which men have

ever grappled. They are such as men may never solve. But the whole wide way upward, from the smallest knowledge the most ignorant possesses to the highest attainments of a Herschel, is a glorious way of truth, and is strewn with imperishable flowers. Every book in our libraries on the knowledge obtained through the means of the telescope or the spectroscope about the Visible Universe is a chronicle of wonderful discoveries. Every new fact disclosed concerning planet, sun, comet, fixed star or nebula, is a mine of beautiful thoughts.

All that we can hope to do in this small volume is to open up a few of the rich facts connected with the broader fields of siderial astronomy, in order that the reader may pursue the subject further in special treatises in larger works. Nothing herein is claimed to be original; it is compiled from many sources; but our hope is that its suggestions will be fruitful of calm reflections upon and interesting outreachings into the infinitudes.

Scope of the Subject.—If space permitted, we should embrace some of the facts, great and small, relating to our own Solar System, but as these topics are to be included in other separate volumes, we shall not, unless incidentally, enter into them.

In speaking, therefore, of "stars," we shall allude only to the so-called "fixed" stars; those which appear not to move from day to day or from year to year. They belong to other systems. They are related to our system only as they are *related to* the whole Visible Universe. They

seem to be comparatively near, but their individual distances are so great that, to the eye which might look at them to-day, and again—were that possible—a thousand years hence, they would be unaltered in position. They form the mile-posts on the high road to, perchance, illimitable space. They make up what the ancients fancied were genuine groups of luminous bodies, representing men and animals, and were by them called constellations, though we know their apparent conjunctions are, for the most part, only apparent.

What of these far-away stars? Are they suns, surrounded by worlds, or mere masses of light? Have they an orderly movement, or do they really stand still? Have any of them just begun to be? Have any of such as formerly were seen come to an end? Do we know, and how do we know, their distances from us? Do they mark the limits of the actual, or only of the Visible, Universe? These are but a few of the long number of queries that come to the mind as one untutored in these things begins to look at the stars and to conjecture this or that.

Is the Universe Infinite?—Frankly, we do not know. No one can know but its Creator. Speaking now of the Visible Universe, we do not know what is beyond it—mere empty space, or, at uncalculable distances beyond, other Universes, whose light never reaches us. But our immediate and Visible Universe itself is probably finite. Astronomers have endeavored for centuries to probe its extent in one direction or another, and, while not successful to a demonstration, they are now

satisfied that the stars which the largest telescopes can discover—at least one hundred millions of them in the aggregate—are, substantially, all that belong to the particular Universe of which our Sun and its planets are considered as forming a part. It may or may not be shaped, in the main, as Herschel supposed, like "a cleft grindstone," yet it would seem to have that general shape; and we, who are near the centre of that " grindstone," or " ring " as others term it, can view the long, thin edge of such a Universe by looking at the Milky Way.

Go out on the green before your door on a clear evening and look upward—either directly over your head, or otherwise, according to the time of year—and you will see running quite straight across the heavens a band of light. It consists, you will observe, of innumerable stars, and also of patches of diffused light, throughout most of its extent. Its sides are not clear-cut and definite, but still they can be traced to a certainty, showing that on the whole the Milky Way has a circumscribed width. To the right and left of it the sky is darker and the stars fewer. This is the famous Milky Way, so-called; sometimes called the Galaxy; and the diffused light throughout most of its scope is called the Galactic light. In the Middle Ages it was called by its Latin name, *Via Lactea*. It is not a continuous band of light, but at a point divides into two branches: hence the expression " cleft " ring. It is not yet a certainty that our own Sun belongs to any of the same immense clusters upon clusters of stars which form

the brighter spots in the Milky Way, but, whether it does or not, that Way brilliantly sets forth the probable general shape of the portion of the Visible Universe to which our Sun belongs.

It is not unreasonable to believe that the Universe, which we know both by our eyes and by the telescope, has a shape, and is not a mere aggregation of stars stretching out every whither, with no plan and no guiding hand. All Nature has a plan and a Planner, and the Planner has given order to the plan. It is, we believe, a plan that is definite, with metes and bounds; what other plans, what other Universes, are beyond our ken, is something not given to us to know.

The belief is also now universal that there is no empty void throughout space, but that there is at least to the ends of the Visible Universe, a luminiferous ether, which permits of the transmission of light and of the force of gravity. It is believed that without this ether no light would reach us from the stars, but that the Universe would be in profound darkness. A curious suggestion has been made that some day there might be communication with distant worlds by wireless telegraphy, the conducting instrument being this ether; provided, of course, that the inhabitants of those worlds, as well as those of the Earth, should construct the proper apparatus, and attempt at the same moment to hold the communication!

Extent of the Visible Universe.—Those faint luminosities, mere patches of light, in the Milky Way, are, when a telescope peers into them, countless stars. Some of them are irresolvable into

stars, and yet may be stars; always excepting certain other (many of them more distant) patches, which are quite certainly nebulæ, of which we shall speak later. It is the great aggregation of stars in the line of vision that makes the Milky Way; that gives it the appearance of one vast ocean of light. This means that, while from star to star the distance may be billions, and even trillions of miles, yet they are at such a distance from us that multitudes of them seem close together and often interblend. It has been demonstrated that "one-half of the light of a star-lit night comes from collective clusters of stars, each of which is totally invisible except in the telescope." Probably, therefore, as we look into the Milky Way, we see farther toward the limit of the Visible Universe than by looking in any other direction.

If the shape of the starry heavens is at all like a ring, we are looking toward the circumference when we look into the Milky Way, and toward the diameter when we cast our eyes upon other stars in other directions. How far from us the farthest visible star is, we may hardly guess at in the light of present knowledge. If we knew its real size, and could also detect its motion, we might figure it out approximately close. But the farthest-away stars have probably not changed in their apparent place in a thousand years. Telescopes have only been in use since the days of Galileo (1564-1642), and a knowledge of how to measure star-distances with any sort of accuracy has only been obtained since the time of Bessel

(1784-1846). How these distances are measured we shall see on a later page; enough now to say that we only know what may be the average distance to the brighter stars, and must make guesses as to the distances of the fainter and, presumably, farthest-away orbs.

The average of the brighter stars are believed to be about two million times farther away than the distance from the Earth to the Sun. The Earth is, in round numbers, 93,000,000 miles from the Sun; that multiplied by 2,000,000 makes the inconceivable distance of 186,000,000,000,000 miles between us and the average bright "fixed" star. Professor Gyldén, a most acute analyst of star data, fixes the parallax of the average of the first magnitude stars at 0.084″, which places them off at a distance of 166,000,000,000,000,000 miles. He may quite likely be in error, but all such figures, great or small, are inconceivable. Professor Newcomb even thought the farthest away stars might be 200,000,000 times the distance of the Sun from us, requiring light 3,300 years to travel over it, and, if so, that there may be a thousand million stars. But he also well says that this is "a very rough estimate."* Certainly if the faintest telescopic stars are really upon an average just as large as those average bright stars (and there is little reason to doubt it), they must be at least two hundred thousand times as far away, If so, whatever that point may be, we must go there before we may feel we

*In *Harper's Magazine*, Jan., 1905.

are nearing the boundaries of the Visible Universe.

Is the Universe of one General Plan?—That is to say, is it made up of suns, with planetary worlds around them, like our own system? Our system, as everybody knows, consists of one central luminary, which, if it were placed as far from us as any of the various stars, would appear like one of those stars. It would be the same kind of a " fixed " star which the most of those are known to be. At the calculated distance of the nearest bright " fixed " star, our Sun would probably be a star of the second magnitude. At the distance of the least-visible, naked-eye star, it would be wholly invisible.

Now, does each " fixed " star, which, as we know is a sun more or less like our own, have planets circling around it, and is that the full and complete scheme of all the " suns " in the Visible Universe? Is this whole known " Garden of God " composed of only one kind of gloriously bright roses, with, as it were, clusters of dark roses attending them as they move along on their beautiful and sublime mission? Clearly this is not the case. The stars are as diverse in size, color and other peculiarities as the flowers of the home-garden; and what is seen may be only a tithe of what is not seen.

Formerly, it could not be proven that there were anything like actual planets revolving around any of these various suns, because they were (as they still are) invisible. Their reflected

light, if they exist, is lost long before it reaches us.

Light travels with speed faster than any known courser, but it loses luster as it travels, and reflected light, in any event, cannot cross half the vast sea of space that separates us from the nearest star. So we have never seen and probably never shall see, even with the largest telescope, the actual face of a planet of another system. Nevertheless, we may believe that planetary bodies exist, because we know of certain large, dark bodies that do circle around some of the other suns. We know this, because they shut off the light of such suns at intervals. In fact, the periods of their orbits have been calculated to a nicety. They are dark stars, which, without doubt, were at one time heated to sun-heat, but are growing to be, if they have not become, planetary, and they have orbits around other bright stars. Such of these as we know of are immense in size; in some cases almost as large as the luminaries around which they revolve; and, if of such size, there is no reason to doubt, reasoning from analogy, that there are smaller planets revolving around the same suns. Such smaller planets, in making a transit across the disc of their central luminary, would not be noticeable from the distance of the earth. Should such planets exist, without doubt they are in all stages of development corresponding with the planets of our own system. Some must be like Jupiter, still hot and covered with vapors and gases, clearly not fit to be the abode of human life, as such life is known to us; others like Mars,

which may or may not be in a condition to sustain vegetation and beings having physical bodies like our own.

But, if some of these stars are the centres of systems similar to our own, there is every evidence that others are wholly different. We sometimes find two suns circling around each other, there being not only a simple but a compound revolution. Some of the suns are accompanied by an immense mass of nebula. Some are in various degrees of intensity of heat, which affects their color. The heavens are full of anomalies. It is clear to every astronomer that there are various systems of suns and (probably) worlds, and that no two can be exactly alike. Nature never does make two things precisely alike; it tends toward unity only through variety.

Giordano Bruno (1548-1600) was burnt at the stake for suggesting, among other things, that the "fixed" stars probably had worlds revolving around them which might be inhabited. It was thought to be placing the Scriptures at a disadvantage to assert that God's great care and love were not wholly directed to the welfare of the "saints" on this little planet. But that day has passed away. Thoughtful men no longer put limits to the creative power, and, this granted, why should they limit that power as to the creation of intelligent beings in other portions of the Universe? "His thoughts are not as our thoughts, neither are our ways His ways." We may well give up once for all our narrow-guage opinion *that what* we see here on the five continents of

this earth is the Alpha and Omega of the Creator's purposes in all the world.

That the various sun-systems are diverse, it is only reasonable to believe. As we journey over this world we see constantly changing scenes. We view prairies, hills, forests, waterfalls, towering peaks; we come upon rocky deserts, and sandy deserts; upon summits tall, but dark with wood, and then upon summits crowned with eternal snows. No two continents are alike; no two countries, no two counties, no two local habitations are alike. No two rivers are the same. No two trees, no two blades of grass, are alike. As we look out into the star-depths, we find there no two groups of stars, no two constellations, no two nebulæ alike. Diversity is everywhere; up and below, and around and within. It is His plan to be diverse; to the Divine eye not similarity but dissimilarity is beauty. If the star-groups are varied, and every object visible in the telescope is of different size and appearance, we may go further, and say that the probabilities are that no two systems of suns and worlds, or of suns and suns, are exactly like each other, or like our own, and therefore that the Visible Universe has not been created upon one single and narrow plan.

Will the Universe Run Down?—In other words, will light and heat one day give out, motion cease, all life die, and "the end" come? Judging from all we see and know yes. This is not to say that the machinery of the Universe is a failure. If it were not made to run forever, but had some other end in view than mere conti-

nuity of existence, then it completes its mission when its final day shall come. Reasoning from everything we know of things composed of matter, we are taught that the end of the Visible Universe is but a question of time. It has a destiny, and that destiny will be fulfilled. Sometimes one asks: Is matter indestructible? We do not know. If created, there can be no reason why by the same agency it might not be destroyed. If intended, however, to be indestructible, still it can change form and become useless for any purposes of sentient beings. All matter is changing. It is changing in the Sun; intense heat must change or continue to change what it feeds upon; other suns are growing and waning, and, as suns, are being blotted out. Like all other things in Nature, they are fulfilling a mission, and eventually reach the end of all created suns—death. Worlds are growing older and altering their conditions. Comets come and go, but eventually are being swallowed up. The final end of all must be so much nearer with every moment of time. Our Sun-system is an immense organism, adjusted with precision to do its momentous work, but when that work is done—let it occupy millions or billions of years, if need be—it is finished; and so it is and must be finite. The Universe will run down because there is nothing to lead us to believe that in its nature it was intended to be eternal.

Conclusion of the Chapter.—These few points about the Visible Universe are named simply to suggest what interesting and far-reaching *thoughts* must occur to the mind of anyone who

looks up into the sky at night and reflects what is going on before his eyes. There is an incalculably immense but finite Visible Universe; it is as varied in detail as is all other created things with which we are acquainted; it is performing a finite mission, which some day will be fulfilled, and it will cease. We do not know what other creations may follow, but this creation, which we now know of as our own local Universe, will wind up its career after the plan of its Author.

With this to show the scope of the theme of astronomy, let us take up some of the various interesting things connected with a closer study of the "beautiful stars," and learn facts about them, many of which are far removed from guess-work or "probabilities," while others are, in the nature of the case, assumed to be true. As to many things we can stand on safe and certain ground, and on others we have the right to surmise, and to continue to gather new knowledge as time goes on.

CHAPTER II

The Progress of Astronomy

What the Ancients Knew.—It is a good place here to speak briefly of the steady, though often slow, progress of astronomy as a science since the earliest human races. What did the former world-dwellers know of the other planets, of the Sun, of the far-away stars? How much were they interested, and did they by searching, or guessing learn anything worth their knowing?

The Bible is not, perhaps, even as to its oldest books, the most ancient publication in the world as to many astronomical facts, yet the book of Job, which may be older than Genesis, speaks of the constellations as if they were perfectly well known. "Canst thou bind the cluster of the Pleiades, or loose the bands of Orion?" was asked by the Lord of Job,* as if Job were well acquainted with these constellations. "Seek Him that maketh the Pleiades and Orion," said the prophet Amos.† "For the stars of heaven and the *constellations thereof* shall not give light," said Isaiah.¶

The Magi were astronomers and star-gazers. They were Chaldeans, and we know, not only from that fact, but from other more certain sources, that the more ancient Chaldeans, who were among the earliest-known civilized nations, studied astronomy as a science. Chaldea began its rise as a nation about B. C. 2400, when Nimrod, "the mighty hunter," set up his kingdom on the banks of the Euphrates. This was 900 years before the time of Moses. It is said that Callisthenes, who accompanied Alexander the Great (B. C. 356-323) to Babylon, sent to Aristotle, of Greece, from that capital a series of astronomical observations that extended back to 1903 years previous to that date, or to B. C. 2234. These observations were recorded upon tablets of baked clay. The

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*Job 38:31. "The Bear" is also mentioned in Job 9:9.
†Amos 5:8.
¶*Isaiah* 13:10.

Chaldeans early discovered the cycle of 223 lunations (lunar months), at the end of which time the moon returned to such a position that the eclipses were repeated in the same order as before. They studied the eclipses and recorded them.

The Egyptians have a history which goes back almost to the time of the Chaldeans, and, some believe, far beyond it. They, too, cultivated astronomy. They knew the Dog Star (Sirius) and called it by name—"Sothis." They began their year with the day when Sothis rose at the same time as the Sun, and recognized the fact that in exactly 365 days it did not again rise with the Sun, but was a quarter of a day late; by which they understood that the true year was 365 1-4 days, and this they called the true, or Sothic, year. The Sothic cycle—when the Dog star again would rise exactly with the Sun—was of 1461 years, and this they celebrated by a great feast. To prove this true they must have had records extending over that long period. Herodotus, the Greek traveler and historian (B. C. 484-424), tells us that "the Egyptians were the first to discover the solar year and to portion out its course into twelve parts." To what extent the Pyramids were "squared and centred" in accordance with exact astronomical facts is too much disputed a subject for us to enter upon, but it is certain that the Egyptians were learned in this science, as they were in many other cognate sciences.

But the Chinese claim to have excelled all other ancient nations in accurate star-gazing. "Of

thirty-six eclipses reckoned by the Chinese sage Confucius" (B. C. 550-478), "no less than thirty-one have been proved true by modern astronomers." But Confucius lived at a late age in Chinese history. Certain "astronomers royal," Hi and Ho, who lived about B. C. 2150, have had their tragic fate described by many Chinese writers. It was their duty to give the king timely notice of eclipses and other remarkable heavenly phenomena. They became drunken for a season and so neglected their duty. An eclipse of the sun occurred which they failed to predict, and the religious rites which ought then to have been given, to appease the anger of the gods, were not performed. These astronomers were seized and summarily executed. The earliest precise Chinese observations which are useful to us date from B. C. 1,100, and are surprisingly accurate. After some 2,500 years of observations, as noted in their annals, the Emperor in B. C. 221 ordered all astronomical records destroyed, and from this period Chinese knowledge of the science declined. The few records that then escaped the flames make us wish that all had been preserved.

We do not propose to follow up what was written by the Greeks, Arabians and Europeans, during the ages intervening between the "Golden Days of Greece" and the Sixteenth Century, because our object is chiefly to show how early men became proficient in star-gazing. Homer (B. C. 900?) called the Great Bear by that name, showing that the constellations were well-known to *the earliest* Greeks. Thales (born B. C. 640)

was the earliest Greek astronomer, and others followed whose reputations were great in their day. Hipparchus[2] (about B. C. 160-125) was greater than any who came before him, and Ptolemy (whose observations covered a period from A. D. 127-151), who copied after Hipparchus, being himself not a remarkable observer, but a man of great learning and keen insight into astronomical facts, received the credit of having written more that contributed to the world's knowledge of the science than any man down to the Sixteenth Century. In fact, between Ptolemy and Copernicus (1473-1543) is a gap of thirteen and more centuries, when almost nothing new was learned concerning the heavenly bodies.

Copernicus was a plain but thoughtful monk, and he it was who first took up in earnest the idea that not the Earth, but the Sun, was stationary, while all the planets revolved around that orb. It was he who gave impulse to a theory which some of the ancients imagined, but did not know, and with him dates all real progress in modern astronomy.

The Fundamental Error.—Up to the time of Copernicus, the fundamental mistake of all the leading astronomers was that the Earth was the centre of our system, and that the Sun and the five known planets and all the other stars revolved around it. It was an accepted fact that the Earth was a flat plain, extending north, south, east and west, to perhaps immeasurable distances, and was fixed on immovable foundations; and that the Sun, *planets* and stars were placed near the Earth

to give it light, and, in the case of the Sun, heat. A moveless centre of all things, and everything created to serve the Earth! Some had taught, indeed, that the Earth was a sphere, but this was not the accepted doctrine. Copernicus altered the doctrine. It took a long time to root itself firmly, but when Galileo (1564-1642) and Kepler (1571-1630), and finally Sir Isaac Newton (1642-1727), came into the field of scientific research, the result was duly accepted, and from that time forward astronomy became a stable and approved science. Their day was the beginning of our real knowledge of the wonderful things to be learned from the midnight skies.

Invention of the Telescope.—The invention of the telescope, or at least its practical application, was due to the genius of Galileo. He heard (1608) that an optician in Holland—and we now know it was Hans Lippershey, a native of Middelburg—had hit upon a combination of lenses through which objects far away could be brought near. Lippershey had, in fact, applied to the government for a patent, but it was not issued.[3] Galileo seized the idea immediately, and in a day's time made a rough telescope out of two spectacle-glasses and an old organ-pipe. It had two lenses, one convex and one concave, and magnified *just three times!* That was the first telescope. He next produced one to magnify eigh times, and finally one to magnify thirty-two time With the last instrument he saw the craters of th moon, the phases of Venus, four moons circlin *around Jupiter*, and curious, ring-shaped Satur

He also observed the spots on the Sun, and resolved some portions of the Milky Way and stars. Persecuted by his church and obliged to recant, with health broken, eyesight gone, and the victim of long imprisonment, he died at the age of seventy-eight, leaving behind a glorious name, and one which the whole world has since honored.

A charming lecturer and a wonderful student, Galileo was in all respects a remarkable man. Those who go now to Florence in search of mementoes of the lives of those whose names are immortal, invariably seek out the Torre del Gallo on the hill, two miles out of the city, and there stand upon what seems to be holy ground. The very telescope with which he looked at the heavens is still one of the treasures of the house in which he lived, and from the tower of which he made his observations; while, nearby, is the house where he spent his last days in quiet and in total blindness, waiting for death, and where he received a memorable visit from the poet Milton (in 1638). His grave is in the "Westminster Abbey" of Florence, the church of Santa Croce.

Since the days of Galileo the telescope has been enlarged and improved two-hundred-fold. Instead of its magnifying thirty-two times, the power has been as high, in some cases, as six thousand times, although the latter is not the successful power with which to look at the stars, or even the moon. The magnifying power magnifies currents of air, as well as the object viewed, and even the great power of one thousand can rarely be used because it distorts the vision.

When the great reflector of the Earl of Rosse, at Parsonstown, Ireland, was constructed in 1842, with its focal length fifty-four feet and its glass six feet in diameter, it was supposed that the acme of mechanical ingenuity in the production of large telescopes had been reached. No such large reflector has ever been made since, and will not be made again, in part because it has been found that refracting telescopes—those by which the eye looks directly at the magnified object, and not at a reflection of it in a mirror—is better adapted to the usual modern methods of stellar research. The largest refracting telescopes in the world are: one in Paris, 49 inches diameter and 192 feet in length; the Yerkes telescope of the University of Chicago at Williams Bay, Lake Geneva, Wisconsin, 40 inches in diameter and 62 feet in length; and the Lick telescope in California, of 36 inches aperture. But many others from 25 to 30 inches aperture are quite as successful in achieving new and important knowledge, year by year, and, indeed, day by day, of the far-away stars.

CHAPTER III

Five Important Astronomical Truths

Fundamental Facts.—In order to understand and appreciate what we shall say, further, as to the enormous distances, varied masses and distinctive peculiarities of the far-off stars, it is necessary to be acquainted with certain fundamental facts *which every* astronomer relies upon to-day as well-

ascertained truths. That there are such known facts, apart from any accompanying guess-work, everybody who thinks for a moment upon—for example—the subject of eclipses, knows. In no other way could eclipses be determined than upon the basis of the exact knowledge of the motions of the moon and Earth with all their eccentricities. The fact that the Earth does not travel at one rate of speed around the Sun; that sometimes it is hastening and then slowing up on its journey; that its orbit is not a circle; that the moon in its orbit pursues the same kind of variation; that the orbits of the planets are not perfect circles; that the planets affect one another by gravitation: all these and other causes for influencing the motion of the Earth and the other planets must be taken into consideration and exactly calculated. But they are calculated; the results are definitely ascertained; there are no mistakes made.

The navigator takes his *Nautical Almanac* in hand, and, by ascertaining the proper location of the stars, learns where his ship is. He finds these calculations made for him years in advance, and he accepts their facts as absolute verities, and such they are. One hundred years from now—a thousand years from now—an eclipse of the sun or moon will occur on a certain minute which can be predicted to-day with absolute accuracy. With equal accuracy the times of the transits of Venus over the Sun's disc, which occur only twice in a century, are noted and the facts verify the predictions. Hence we know beyond any dispute at least some precise things about our Solar System.

and it is this certainty of knowledge which forms the only basis for extending our knowledge beyond the Solar System.

The five facts alluded to are the following:

1. That the velocity of light has been definitely ascertained to be about 186,360 miles per second, or about 6,000,000,000,000 miles per year. The method by which this was first known is a most interesting one. It consisted in calculating to a certainty when the moons of Jupiter should be eclipsed, their exact periods of rotation having been first ascertained; and then, by observing the difference between this calculation and the real moment of eclipse as visible to the eye through the telescope, the velocity of light was proven. Römer, a Danish astronomer (1644-1710), discovered this difference in 1675, and at once attributed it to the time that it required light to pass from Jupiter to the Earth. In other words, he realized that he did not see the eclipse at the moment it occurred, but later, when the actual light from the particular moon which was being eclipsed as it passed into Jupiter's shadow, reached his eye. Römer thought that this delay amounted to (when the Earth was the farthest away from Jupiter) twenty-two minutes. His observations were not as exact as those which are made now, but he had the correct idea and was not far astray. In various other ways it has been proven since that light, which is the quickest messenger in the Universe, travels about 10,000 times as fast as the Earth travels in its orbit; that it requires about 8 *minutes* and 18 seconds for light to travel from

the Sun to the Earth; and this knowledge is a most important factor in making any precise calculation upon what is going on either within or without the Solar System.

2. That the Sun is approximately 93,000,000 miles from the Earth. Probably the most accurat : calculations give the distance as 92,874,000 miles. This has been measured by what is termed the solar parallax, which has been verified, so far as ssible (but not with much success), during the . :t two transits of Venus, and has been still better verified, under one of Kepler's laws, by the ascertained distance of Mars. To get an idea of the distance from us to the Sun, it is only necessary to suggest how long it would take to travel to that orb upon an express train going day and night at thirty miles an hour. The time required would be 353 years. At two cents a mile one-way fare the journey, made in such an express train, would cost $1,860,000. Had one started on a journey in 1552, just preceding the reign of Queen Elizabeth, and had he lived so long, he might have reached the sun this year (1905). This Sun's distance is the astronomer's "foot-rule" for measuring space. Without a knowledge of it no star-distances to points in the Universe could be gauged.

3. That the weights of the Sun and planets are not according to their apparent mass. Volume does not determine mass. The Sun's density is known to be only one-fourth that of the Earth. To many it will seem incredible that the weight of the Sun, or any distant planet, or even of the

Earth can be ascertained; but, marvellous as this may be, we do know the exact size and weight of the Earth, and can approximate very closely to the size and weight of the Sun, and to the other members of the Solar System. The mass must be first determined, and then, the force of gravitation by each body upon the other being ascertained, the rest is a matter of simple calculation. Even when the density cannot be determined, the mass may. The density of the stars is a difficult matter to conjecture, much less calculate. We know, however, that the Sun's mass is 330,000 times that of the Earth; that its real volume is 1,300,000 times that of the Earth. The Earth's weight is 6,069,000,000,000,000,000,000 tons and the Sun weighs 1,910,278,070,000,000,000,000,000,000 tons. Mercury is one-fifth denser than the Earth; Venus is less than nine-tenths as dense; Jupiter one-fourth, and Saturn one-eighth as dense. The weight of each planet has been computed.

4. That gravitation is inherent in all matter and by fixed law. Everything on this Earth is held down to its surface by the strange, unseen, yet powerful grip of gravitation, without which the apple would not fall to the ground, nor could men in China walk with their feet toward the feet of the men in America, both going along with equal ease. Gravitation is one of the most powerful, most exact and most mysterious influences in Nature. Every planet attracts every other planet; every star, every other star; every atom in the *Visible* Universe attracts every other atom.

" There is no known distance to which the attraction of gravitation extends," say the astronomers, although gravity loosens its hold in a compound ratio as space separates one material body from another. The distance between our own Solar System and the " fixed " stars is so great that the attraction between them may be for all practicable purposes almost an infinitesimal one, yet the attraction exists, and, if the Sun were not moving, so as to overcome such attraction, it would hasten toward the nearest attracting star. Sir Isaac Newton first discovered this law, and its truth has been proven in numerous ways since. So plain a matter as the relation of the moon's gravitation to the Earth's tides was a mystery until Newton's law was revealed, and then it became clear enough. Julius Caesar knew in his day, as we gather from his accounts of his first expedition into Britain, that the moon affected the tides, and so did the ancients long before him, but just how they did not correctly conjecture. Without the law of gravitation, there would be utter confusion in the Solar System and in all other systems of stars.

5. That every planet and every star is in motion and must be in order that gravitation toward other bodies may not cause their destruction. The motion of the Earth is swift enough—nearly 19 miles per second—to carry it on in its nearly circular orbit around the Sun, yet the attraction of the Sun keeps it in that orbit. The two forces are mutually counteractive. It has been calculated that so exactly do these two forces correspond

that, in the course of 2,500 years, the earth is only one-sixty-sixth of a second behind its time in its annual revolution, a difference caused by tidal friction; and this shows the marvelous exactness of the laws of Nature, designed by a Creator who makes no mistakes. Let him who will suppose this is a matter of chance; the thinking mind will see in it a law laid down by an omniscient and omnipotent Lawgiver. His laws are so beautiful and so exact that the stars in space are never likely to collide except by His fixed purpose. Every planetary orb and every star must move, or there would be constantly the "wreck of matter and the crush of worlds." Long before it could be announced as a proven fact that the stars are in motion, the discoveries of the law of motion in the Solar System led inevitably to the belief that all the "fixed" stars must also be in motion. The fact is also probable that all the stars rotate on their axes, but there cannot be, at present, any proofs of this, beyond the fact that it seems to be a law of our system.

These foregoing five propositions, which we have called fundamental truths, by no means exhaust the primary facts which will throw light upon our study of the phenomena of celestial geography and celestial marvels. But, perhaps, they are sufficient for ous present purposes.

CHAPTER IV

Star Distances and Magnitudes

Distance to the Brightest Star.—Copernicus thought the stars were at "an infinite distance" from us. But with our measuring rule of the Sun's distance in hand, and with our knowledge of the philosophy of light, we may ascertain, at least with some near approximation, how far off the nearest of the "fixed" stars are. This very night as these lines are written, the writer has been looking at an exceedingly bright first magnitude star in the southwest, hitherto alluded to as well-known to the ancients—Sirius, or the Dog Star. It is a white star—bluish-white—and is to our eyes the brightest of all the stars. The planets Venus and Jupiter are, at times, apparently larger, but as these planets shine only by borrowed light, they are in reality much less lustrous to us than Sirius, which gives out four times as much actual light as any other one star visible in the Northern Hemisphere.[4] We shall refer again to Sirius, but now what of his distance from us? Being the brightest, is he not the nearest of the "fixed" stars?

The reason there was long a desire to know the distance of Sirius from the Earth was not only because he was so (apparently) near, but because, if we had this measure, we might possibly gauge the distances of other stars approximately as bright. The stars of the first magnitude are few in number—from fourteen to twenty, according to different lists—and only a part of these are vis-

ible at one time; not all of them at any time in the United States. Naturally these greatest stars, as they seem to us to be, are the ones to which the attention of astronomers would be first directed, and in which, certainly, casual observers would feel most interest.

Formerly astronomers believed that Sirius was the nearest to us. We now know that this is not true. How do we know? Simply because, by obtaining what is called his parallax, it has been found that he is three times further away than at least one star now believed to be the nearest.

This matter of obtaining a parallax on any "fixed" star is exceedingly difficult. To obtain the parallax of Sirius the astronomer accurately observes the exact place in the heavens where Sirius is, say to-night. The precise location and angle in the line of sight is noted. Six months hence, when the Earth is on the other side of the Sun, 186,000,000 miles from where it is to-night, another similar observation is taken, and one-half of the displacement is used as the basis for measurement. This tremendous base-line is not yet far enough to discover any alteration whatever in the position in the heavens of most of the stars, but in the case of Sirius it will be found that he has moved a sufficient amount to allow of a calculation. Due allowance has to be made for the proper movement of both Sun and Earth in the meantime through space, and also for the proper actual movement of Sirius; but after this is done, and the angles are computed in connection with the

known length of the base-line, it is simply a problem in trigonometry to figure up his distance.

The same thing can be done on the Earth itself, to ascertain distances between the observer and some point within his range of sight. For example, one may determine the angle of sight from one's house to a tree several miles distant; then walk to another point, say half a mile away, to another house, measuring exactly the distance between the two points of observation, when another angle is taken. Then, taking half the distance of the base-line as the displacement, it can be calculated to a fraction whether the tree is one, two, or five miles off. If only the base-measurement has been accurately made and the angle measurements are equally accurate, the result will be certain. This method of measurement is taught in all the college text books.

Now, in the case of Sirius it was, at first, not easy to secure a true parallax. It was found to be very far away for such a purpose. But at last it was ascertained to be something, and that something was a trifle less than four-tenths of a second (0.39″); an exceedingly small amount, but enough for calculation. Figuring on that basis, Sirius was determined to be approximately 528,884 times farther away from us than is our own Sun. This means that his distance, when expressed in miles, is about 93,874,000 multiplied by 528,884, or 49,648,456,616,000 miles. In round figures, fifty trillions of miles!

Measured by light-years this means that when we are looking upon Sirius we see that star not as

it is to-day, but as it was over eight years ago. Traveling at the inconceivable speed of 186,360 miles a second, his light has taken 8.6 years to reach us. Or, to put it another way, an express train going at thirty miles an hour would require 188,921,067 years before it could take a traveler from the earth to Sirius.

Immense beyond all conception as this distance is, it is but a trifle compared with the probable distance to some of the fainter stars. The truth is, the vast majority of the stars are so distant that they defy distance measurement. Had we telescopes sufficiently powerful to detect in them a definite movement in the course of six months, or even in the course of fifty years, their distances might be measured. That such distances cannot be computed is not the fault of the rule, but because of the vast space between those stars and our own system. We are sure that Sirius is no nearer than has been named; he may even be twice as far away, since some of the astronomers declare they have found his parallax to be only 0.16″ which is the amount assumed by that recent clever writer, Sir Richard Proctor, in his *Our Place Among the Infinities.*

Does not this preliminary survey of the position of the brightest star of the midnight skies make us astonished and compel us to wonder, beyond all power of language to express it, at the tremendous heights and depths, and lengths and breadths, of what we call space? It is surely beyond human reach or fathomings, except as mere figures, which *convey little* meaning to the mind, express it.

Distance to the Nearest Star.—We have said that Sirius was not the nearest known star. Three others are nearer, and only three, so far as has yet been demonstrated. The nearest star is believed to be Alpha Centauri, which is a star of the Southern Hemisphere, and which is calculated to be *at the least* twenty-five and one-half trillions of miles away (25,546,488,716,340). No astronomer now fixes it at a less distance. Light takes 4 years and 4 months to reach us from that star. But an express train going at thirty miles per hour would take a hundred million years to reach it. The star 61 Cygni and a star in Ursa Major (the Great Bear) are each somewhat further off, but nearer than Sirius. Professor Newcomb well represents the distance to the nearest star by using this illustration: "Represent the orbit of the Earth around the Sun by a lady's finger-ring. Then the nearest 'fixed' star would be about a mile and a half away."

Distance to the Farthest Star.—If these appalling distances take us only to the nearer stars, what is the measure of space to those farthest away? This no one knows. Most stars below the fourth magnitude seem to be, as a rule, too far off to have a parallax. The apparent diminution of magnitude, therefore, is believed to imply actually increased distance. So the astronomers lay down a general average of star-distance about as follows: The average first magnitude star is as far off as requires light 15 1-2 years to reach us; second magnitude, 28 years; third magnitude, 43 years; and so on to the twelfth magnitude, 3,500

years. It is certain there are comparatively few stars at a distance beyond those of the twelfth magnitude, because close searchings of all parts of the heavens reveal a paucity of stars of greater magnitude, and no such amount of star-light as should come from invisible stars beyond. If this be true, it implies that here, in the territory of twelfth magnitude stars, is the beginning of the border-land between the Visible Universe and a great void.

Such a conjecture gives, then, as the mean distance in any direction toward the beginning of the finite end of the glories of the heavens around us, 20,566,360,080,000,000 miles. This must be doubled for the full extent of the Universe, if our Solar System is anywhere near the centre of it,[5] because this calculation can be for only one direction. Double this number makes about forty-one quadrillions of miles.

It is scarcely likely that a telescope will ever be constructed which will permit us to secure a parallax, and so even approximately measure off the space that lies between us and those orbs whose light comes to us in faintest measure from the farthest-off portions of the Universe. It is at the least certain that if most of the apparently smaller-sized stars could be blotted out of existence tonight, they would continue to shine and twinkle to human eyes for several thousand years hence. This simply means that it would require such long periods for the light of the destroyed star to finally reach our Earth.

If we assume that there is an outermost rim to

the Visible Universe, we know that long before we might reach that point our own Sun would be absolutely invisible to the naked eye, since in size and radiance the Sun, which shines upon us daily with such wonderful lustre and brightness, only ranks among many of his fellows of the first magnitude as a third or fourth magnitude star. The Sun is really but a child in size compared with some of the monster suns in the Universe.

The distances of the stars, then, are beyond what the human mind, as now constituted, can apprehend. As Mr. Proctor has well said: "As reasonably might an infant hope to pour out the waters of the ocean into a hollow, scooped with his tiny fingers in the sand, as man to picture in his narrow mind the length and breadth and depth of the abysses of space in which our Earth is lost."*

Magnitude of the Stars.—"One star differeth from another star in glory." It is so to the naked eye; it is far more so through the telescope. "Magnitude," as the word is used by astronomers, is a misleading term; it ought to be applied to real size, but as used in the textbooks it means apparent size. Very early in the world's history —at least as early as the time of Hipparchus— the stars were classified into first, second, etc., magnitudes, up to the sixth, which latter represented the smaller stars that were visible to the average naked-eye. Ptolemy made the earliest catalogue of stars that has come down to us (following that

**The Flowers of the Sky*, p. 19.

of Hipparchus, who had previously catalogued them about B. C. 125) and he gave the number as 1030. The next catalogue, made in the Fifteenth Century by a Tartar astronomer, whose name was Ulugh Beigh, gave 1019, and the next, in the Sixteenth Century by Tycho Brahé (1546-1601), a Danish astronomer, gave 1,005. These numbers were small compared with the real number visible, because the observers could not take observations from all the view-points of the Earth. The more commonly used recent star-catalogues show the following to be the number of stars visible to almost any eye, to 35° south latitude:

Of Magnitude	1	about...			14
"	"	2	"	...	48
"	"	3	"	...	152
"	"	4	"	...	313
"	"	5	"	...	854
"	"	6	"	...	2,010
Total.....					3,391

Pickering, the astute Harvard astronomer (still living), has counted and charted 4,260 stars visible to the naked eye at Cambridge. Some very keen eyes may see stars of the seventh magnitude, but these are usually classed among the telescopic stars. A very few stars have been classed as of the sixteenth magnitude.

The above table shows that from any one point on the Earth's surface, the actual number of visible stars, as seen by the average person, is com*paratively small.* Probably about 2,000 stars ar

all that are usually visible, and 3,000 would be an outside limit for the keenest eye.

It will also be observed that the number of these stars increases as their apparent size grows smaller and smaller, and this average increase is about three-fold. Based upon this seeming law of increase it can be readily calculated that there should be about 118,688,490 stars of the sixteenth magnitude, which are the smallest-sized stars visible in the largest telescopes. Adding them all together it would indicate that the Visible Universe might contain about 178,033,111 stars. But, as stated, the stars thin out amazingly after the twelfth magnitude, and so it is believed that one hundred millions may be the utmost limit of all the visible stars.[6] In this connection it is of interest to note that the largest star catalogue published in one chart was first prepared by Argelander, a German astronomer (1799-1875). This, as later extended by Schönfeld, contains 457,856 stars, to which must be added enough charted in the Southern Hemisphere by Gould to make something like 600,000. The great bulk of all the telescopic stars have never been charted.

As has been hinted, there is no certain rule agreed upon among astronomers to determine whether a star is of this apparent magnitude or that. They do not agree upon the proper scale. Some exceedingly fine instruments have been constructed for the express purpose of obtaining a gauge-basis, but still the question of what size and brightness, combined, shall constitute a so-called certain magnitude, is an open one.

When we come to the question of real magnitude, apart from what is apparent, that presents a different and much more difficult problem. If the distance between the Earth and the star cannot be told, even approximately, real magnitude cannot. But, given the probable distance, and given the distance between that star and another star around which it revolves, or which revolves around it, and, their velocity being also known, it is possible, under the computed force of gravitation, to figure the mass. For example, it has been demonstrated that the star Algol in the head of Medusa (a variable star, having a velocity of 26 miles an hour) has a companion only 3,220,000 miles from it, with a velocity of 55 miles an hour; and that Algol's diameter is 1,061,000 miles, about a fourth more than that of the Sun, but with a mass only four-ninths of the Sun's mass, or about one-third of the density of water. We evidently have in Algol a star in a state tending far more to gaseousness than the Sun.

Are many of the stars larger than our Sun? Are many of them smaller? These questions must be answered affirmatively. "One star differeth from another star in glory," and this applies both to magnitude and brightness. There are stars several thousand times the size of our Sun; there are stars not a quarter so large as the Sun. But to ascertain the exact volume of any star is a matter almost impossible to do. Gravitation acts on and from mass, not size, and the calculation of the masses of stars are based upon their gravital force, *whereas nothing* except telescopic measurements,

which cannot be made as to the physical body of the stars, would be required to discover volume.

To illustrate the fact that the force of gravity depends on density and not volume, we may refer to the common test which was first made by Galileo from the Leaning Tower of Pisa. He dropped from the top of the tower two weights, one ten times as large and heavy as the other, and, as both came to the ground at the same instant, it was proven that gravity makes no note of volume but simply of density. The atoms of the iron were alike in both masses and so were equally attracted. Another illustration is that of the planet Jupiter, whose mass is but 317 times that of the mass of the Earth, although its volume is 1309 times that of the volume of the Earth. Jupiter's power of gravitation has been proven not to equal the number of times of its actual size over the size of the Earth, but is only in proportion to its actual mass.

Accordingly, the mass of a star may be ascertained very closely, but yet the question of its volume may be an open one. If a telescope could get at the exact disc of a star, then its volume might be computed, but the disc of a star can rarely or never be accurately viewed; whether from the intensity of its own light, and its distance, or because also of the conditions of our atmosphere, the fact remains that most stars twinkle to the eye, and also have that uncertain and indeterminate glare about them which precludes definition. This is so as to the disc of Sirius, the apparently largest of the near stars.

Nevertheless, we know that there are all de-

grees of volume, and all degrees of masses in the stars, and as to the great bulk of those which are so far away, no one can affirm which is the larger and which the smaller with any nicety. Like their number, their true magnitudes are usually sealed from human knowledge. But it is known that stars of the class of Sirius and Arcturus, are, as compared with our Sun, enormous in volume (Arcturus is nearly as bright as Sirius, and yet is at least twenty-two times as distant), while others approximate more nearly to the magnitude of the Sun.

As to the relative brightness of the stars, the English astronomer, Mr. J. E. Gore, reports in January, 1905, as a result of his various and most recent calculations, that Polaris is 27 1-2 times as bright as the Sun; Aldebaran 35 times; Capella 128 times; Regulus 642 times; and Arcturus 486 times.

Star Constituents and Temperatures.—The spectroscope shows that the constituents of the stars are usually very much like those of our Sun. In the white stars it is apparent that these constituents are more attenuated, in the yellow stars that they are very similar to the Sun, and in the red stars that they are more condensed. About eleven-twelfths of the stars show a spectrum more or less like the Sun. The Sun is believed to consist of various vapors or gases, compressed together by the force of gravitation. The denser, central mass is surrounded by a radiant envelope of condensed metallic clouds, floating in an atmosphere *of glowing gases.* These gases are believed

cooler than the mass within, because of their contact with the coldness of outer space, which, whatever that is,[7] would be the temperature of our Earth but for its internal heat, and the fact that our atmosphere accumulates and retains the rays of the Sun. The temperature of the Sun itself has been computed to be 18,000 degrees Fahrenheit. Some of the stars must have a temperature very much hotter, and others very much colder.

A writer has recently suggested that radium, the new substance which has been found in such infinitesimal quantity that one ounce of it would be worth $3,000,000, and which maintains its own temperature without combustion or chemical change, and with no perceptible decrease in energy, might exist in sufficient quantity in the Earth, and, for that matter, in the stars, to furnish internal heat for an almost indefinite length of time, but too little is known of it to make this more than guesswork.

CHAPTER V

Sirius, the Dog-Star

General Facts About Sirius.—Since Sirius is the brightest known star in the heavens, and has received as much attention as any one of the stars of the first magnitude, some words upon him in addition to what has been said may be instructive.

It seems to be certain that Sirius is a Sun still "young" as to condensation, and, because of his more attenuated condition, from 1,000 to 3,000

times larger than our own Sun. His light, however, according to latest (1905) estimates, is only 33.4 times as great as the Sun, and, if it could be massed as solidly together as the main body of the Sun, it is thought that his mass would not exceed four and one-fourth times the Sun's mass. Yet, if he could take the place of the Sun, at the same distance from us, his light and heat (if thirty-three times that of our Sun) would destroy every creature upon the Earth at once. Life here, animal or vegetable, would be out of the question.

Homer speaks of the splendor of Sirius " when new risen from the waves of ocean," and all the astronomers and poets of the ages since have referred to his beauty. By many it has been supposed that Sirius has changed color since the days of the Greek astronomers, a matter which will be referred to presently. Hesiod (about B. C. 735) first mentions him by name and connects him with the " Dog-days." The so-called " Dog-days " were anciently supposed to commence twenty days before Sirius rose with the Sun and end twenty days after that date. In Hesiod's day the " Dog-days " began on July 3 and ended on August 11, but now Sirius does not rise with the Sun until a few days after the "Dog-days" are past, owing to what is called the Precession of the Equinoxes.[8] The Egyptians worshiped Sirius under the name of Sothis (and other names), and represented him in hieroglyphics as a man with the head of a dog. They ascribed to him the inundations of the Nile.

If our Sun were placed where Sirius is, how would he look to us? This has been carefully com-

puted, and it is found that the Sun would not be visible to the naked eye except as the merest point, being 6.2 in magnitude. Were the two alike in density and their surfaces equally brilliant, then it would mean that Sirius would have 253 times the mass of the Sun. Its greater brilliancy, therefore, is due both to his real volume and more intense glow.

The brightness of Sirius is so great that Sir William Herschel tells us that when that star was about to enter the field of view of his forty feet reflector, "the light resembled that which announced the approach of sunrise," and, when it entered, " the star appeared in all the splendor of the rising Sun, so that it was impossible to behold it without pain to the eye."

Has Sirius Changed Color?—As has been stated, it has been popularly supposed, even by astronomers, that Sirius has changed color since the earlier days of his history. The ancients speak of him as a " red " star, but we now know he is of a bluish white color, although changing in shape, according to whether we see him through the clear air of the upper sky or the denser air near the horizon. Seneca (B. C. 4—A. D. 65) says his redness was more marked than was the case with Mars. But it is believed that Sirius was usually viewed when near the horizon, where even now it often happens in Southern Europe, as with us, that his color to the naked eye seems ruddy. The better opinion seems to be that his color has not really changed to any appreciable extent within any historic period.

There are some stars, however, that do change in lustre and in color. The star Mira in the Whale is yellow and then becomes white, and again relapses into yellow, but this change is periodical. If Sirius has changed, it is a permanent change, which is unlikely during so short a siderial period of 2,000 years from anything we know of the constitution of stars. In time, to be measured by millions of years, substantial changes must occur; changes that would alter both the amount of light and heat and, therefore, the color; because each star is believed to have its growth from white heat to the cooler glows of yellow and red.

Sirius is not only bright, not only immense in size, a " giant among the suns," but he has a near-traveling companion-star of the tenth magnitude, first detected by reason of the irregularity of his own motion. This companion was not seen until found in 1862 by Mr. Alvin Clark's powerful 18 1-2 inch refractor at Boston. Its position had been determined theoretically four months earlier by an American astronomer, Mr. Safford (b. in 1836), and its finding was a splendid proof of the close calculation that learned astronomers can make of unseen heavenly bodies whose attractive forces they are able to compute. The calculation was based on the uneven motions of Sirius himself. The companion is called a " close companion," but still is about two billions of miles from Sirius. It revolves around Sirius in abou fifty-three years, and is closely equal in mass our own Sun, i. e., one-fourth the mass of Si *It is partially* a dark body, but still may sh

part by its own light. When it cools off sufficiently to make a planet and contracts to the size of our Sun, what a gigantic planet it will be, of nearly a million miles in diameter! That it is quite a dark body is certain, since in the great Lick telescope it is barely visible, whereas had it the brightness of most of the stars it would be plainly seen. In the course of ages, as it grows to be a dark planet, it will pass away wholly from human sight.

Not only do we know of this "close companion" of Sirius, but five other companion-stars have been seen each comparatively close to Sirius, perhaps the least of them at present exceeding our Sun in volume, though also nearly dark companions. It would seem as if here is a system of dark suns, some at least revolving around Sirius, and all revolving around some common centre.

A great sun like Sirius, with at least six close companion-suns circling around it, or circling with it, would naturally, according to our human way of thinking, be the centre of a system of many real planets. But dark bodies, shining only by reflected light, although of the size of Jupiter, cannot be seen at the distance of Sirius by any telescope yet manufactured. The whole starry heavens may be more full of planetary worlds than of stars, but to no mortal eye are they disclosed by any apparatus that has yet been invented.

The motion of Sirius through the heavens, which was announced first by Halley (1656-1742) in 1718, has been calculated with much exactness. He is at present moving southward and westward, and also away, from our system, at

about 33 miles per second. In the line of sight he is receding about 19 miles per second. To make this swift apparent motion appear to us, however, to amount to as much as the space of the moon's diameter, would require 1450 years, so that it is easy to be seen how little the heavenly bodies have moved on the visible face of the skies since the beginning of the Christian era.

CHAPTER VI

Binary, Multiple and Variable Stars

Single Stars May be Double Stars.—The preceding chapter has prepared the reader for some knowledge of those great marvels of the heavens, the binary (double), the triple, the quadruple, and other multiple systems of suns. Our Solar System has but one Sun. Possibly most of the star-systems consist of one sun, and then (as we doubt not) of many planetary worlds; because most of the stars appear to be isolated. But not so all. We have seen that Sirius has in his system a number of other and darker suns. There are systems similar to his, but in general they are of every kind of variety in numbers and composition.

There are many of the stars which are single to the naked eye, and no one would judge them to be other than solitary stars. They shine and twinkle like burning points of light. But the telescope resolves those points into two or more stars. Mizar, which is the middle star in the tail of the Great *Bear (in the* " handle " of the Dipper, as popular-

ly called) can to a very keen eye be seen to be double, though to many eyes it is one single star. In an opera-glass it is plainly double. In a large telescope it is found to be triple.

A star in Auriga is really two stars, separated by only 7,500,000 miles. They cannot be seen except as one even in the big telescopes, but the spectroscope proves they are separate stars. They are traveling nearly 70 miles per second around a common centre and the period of revolution is only about four days. Each star is heavier and larger than our Sun, so that the speed they travel in their closed orbits is terrific. Spica, in the constellation Virgo, is a wonderful double, the two being only 6,000,000 miles apart, and making a revolution in four days. There are at least 10,000 apparently single stars, which the telescope shows are composed of two or more stars each, and this only takes us to stars of the tenth magnitude, as those of smaller magnitudes are irresolvable into binaries, etc., by the largest telescope made.

The binary stars either revolve around each other, or around some unknown centre of gravity far away, in definite periods, which, so far as known, vary all the way from 11 1-2 to 1625 years. Their orbits are sometimes very elliptical. There are other double stars which are not seen at all as double in the telescope, but are known to be so by the changing lines of the spectrum. In other words, the spectroscope may show the existence of two large bodies as composing one star, when to the telescope the second star is wholly invisible. This will happen, of course, only when the invisi-

ble star comes between us and the visible star, and shuts off a portion of the latter's light; or when the two stars are so near together that, while the telescope cannot resolve them, the spectrum shows that one part of the apparent single star body is moving in one direction away from us and the other part in another toward us. The spectrum shows orbital motion, if approaching or receding, and by it not a few binary stars have been proven to exist.

There are two kinds of binary stars: *apparently* double, and *actually* double. One star may have no relation to another, but be in the same line of sight. In that case it is called apparently, or "optically," double. The other class is actually double. In the densest portions of the heavens in the Milky Way, where "star lies on star," there are numberless optical doubles. They are in such clusters of hundreds and thousands that at our distance it is impossible for some not to be practically behind others in the line of sight, though just enough separated to the telescopic view to be seen to be double. Binary stars usually revolve around each other, or both around a common centre. This condition of things is unknown to our Solar System, but we must expect to find many things different in other parts of the outside Visible Universe. Jupiter must have been once a small sun revolving around our own Sun, and the Earth a still smaller sun, full of light and heat, and lighting up our moon. Conditions change; everything in the Universe is changing. The heavenl bodies are in different stages of cosmic state. I

the Nebular Hypothesis be at all correct, we must be prepared for all sorts of divergences in the visible orbs in space. Separations and segregations must be endless in variety. And such the telescope and spectroscope reveal the facts to be.

Triple and Multiple Stars.—There are triple stars; stars that resolve themselves (like Mizar) into three separate suns. There are quadruple stars; stars that resolve themselves into doubles, and each of these into double stars. There are sextuple stars; stars that divide into doubles, and each of these into doubles, and then two of the doubles into doubles: a marvelous transformation, surely.

It must be kept in mind that the relations of these stars to each other are not always clear. They are not always physically connected in one system. But when so connected, and supposing them to have various worlds girdling them, how wonderful it must seem to the inhabitants of those worlds! Sometimes two suns will appear above the horizon, sometimes three, perhaps even six at one time, each of varying size. When all are above the horizon at once, the light and heat may be what to us would be insufferable; yet such may be their distances that on the whole such light and heat would not be excessive even for beings like ourselves.

Groups of Stars.—What is still more startling is that one system of stars—an immense system, of course, as compared with our small Solar System —may be composed of not two, four or even six, but hundreds of suns. Such a system is called a

"star cluster." "They are collections," says one authority, "often on the grandest scale, of sunlike bodies small and large, united in origin and history, acted upon by identical forces, tending toward closely related ends."

Such is the wonderful group of the well-known Pleiades. Everybody knows, or ought to know, the "seven sisters" of the Pleiades, the same mentioned by Job, and which have probably not changed their position to the naked eye one particle since his day; although it is believed that at least one of them (Pleione) has increased in lustre. The Hindoos thought they were the centre of the heavenly Universe and the abode of Deity. On November 17, when the Pleiades was overhead at midnight, "no petition was ever presented in vain to the ancient kings of Persia." Savage tribes in various lands and islands of the sea have held these stars in peculiar reverence. Among the seven chief stars of the Pleiades, the telescope shows a star cluster whose richness will scarcely be believed by one who has never seen it. In this star cluster, by the combination of the telescope and photography (photography gathers in on a sensitive plate stars not visible in the telescope to the eye) 2,326 stars have been counted, and with nebulæ intermixed!

The Pleiades is probably nearly 1,500,000,000,000,000,000 miles from us, and the light we see from its stars, to-night, probably left those luminous bodies 250 years ago! They seem small because of this vast distance, and yet Alcyone, the brightest of the seven chief stars, is probably 1,000 times

as brilliant as our Sun, Electro 480 times, and Maia 400 times. Sirius, himself, is believed to be small in actual brightness compared with the five chief members of the group. The other 2,000 and more suns of the cluster are all smaller, but many or most of them are larger than our own Sun. This is all inconceivable, of course, and yet the Pleiades is nowhere near the rim of the Visible Universe, for, as we have seen (in Chapter I) that must be many times farther away.

At present there are about 500 of these star-clusters known to the astronomers. They are of all sizes, and, as to component parts, of all numbers. Some look through the telescope like flocks of birds, stretching out to a considerable length, but narrow in width; some are almost round, like a bunch of beads; some have clusters within clusters. In the constellation Hercules, toward which some astronomers believe our Solar System is now moving, is a cluster once estimated by Sir William Herschel to contain 14,000 stars, but now believed to really contain about 4,000. From one side to the other of the cluster, the distance is about 558,000,000,000 miles; light would require thirty-six days simply to cross it, while it takes about sixty-five years for the combined light of the cluster to reach us. Each star, if uniformly distributed about this system, would be ten times as far from any other as our farthest planet (Neptune) from our Sun. To the inhabitant of a world situated amid six of the largest stars of the group, these suns, if above the horizon at once, would

have a lustre much less than our own Sun has upon the Earth, because of these distances.

One of the stars in the constellation Centaurus is a fourth magnitude star, which Sir John Herschel, when using his large telescope at the Cape of Good Hope, described as a "truly astonishing object. All clearly resolved into stars of two magnitudes, viz., thirteenth and fifteenth, the larger lying in lines and ridges over the smaller." Another astronomer (Mr. Gore) computes that it contains 15,000 stars. One star to the naked eye—15,000 stars in the telescope!

It is only too apparent from these facts, that, when the probable number of all stars in the Visible Universe (as visible through the most powerful telescope) is fixed at not less than *one hundred millions*, there is little likelihood of exaggeration in the estimate.

Variable Stars.—Some stars are variable; that is, they grow brighter and dimmer by turns. It was at first thought that this phenomenon was always connected with the conditions of these stars themselves, but inasmuch as our Sun, notwithstanding great fluctuations in its solar atmosphere, gives forth, practically, the same light day after day and century after century, it was decided that some other cause must be found. Some of the stars whose light thus changes vary from minimum to maximum brightness in the short period of one day, or even less; others require nearly two years. Some appear as eighth magnitude stars (which are invisible to the naked eye) and then *increase in* brilliancy to the first magnitude. On

the whole about 300 stars are known to be variable, and all of them—for no known reason—appear to be among the stars farthest away.

The telescope cannot reveal the reason for this variableness, but the spectroscope may show the presence of a smaller body revolving around the star and coming between the star and the eye of the observer. It is really a star eclipse. The reason the same thing does not happen in the case of what are known as binary stars, is because the second star is also as brilliant, or nearly so, as the star which it might hide, should its revolution be in the line of sight, and, again, most of the binary stars do not revolve around each other in the line of sight. What we usually see, therefore, in the cases of variable stars, are star eclipses. The obscuring body may not always be a totally dark one; it may be a sun partially dimmed, and so somewhat darken the brighter light. But in some cases the body must be wholly dark; "cold, dead suns," revolving around other suns in the line of our vision, and yet often so swiftly, and so nearly in contact with the central orb, that it requires but twenty-four hours to make a total revolution. In the case of many of such close stars, it is more than probable that both bodies are almost wholly gaseous, and, therefore, not real suns at all, but stars in an early stage of sun-creation; a fact seemingly proved by the spectrum.

There are, again, some variable stars that cannot be explained on the hypothesis of darker bodies obscuring them in their revolutions. Their increase and decrease of light are not of definite

periods, and the lines of the spectrum show sudden changes in such stars themselves, the hydrogen lines (conspicuous always in stars approximating the conditions of a gaseous body), being most prominent at the time of the maximum brilliancy. The conclusion naturally come to in such cases is that, from some unknown causes to us, the star is in a state of fluctuating internal excitement, increasing in brilliancy a hundred- or a thousand-fold on certain occasions, and decreasing sometimes as suddenly, but sometimes gradually. We are now approaching, however, the subject of solar conflagrations—"suns in flames," as Mr. Proctor expresses it—and this will be noticed in the next chapter.

CHAPTER VII

Star Conflagrations and Star Colors

Does a Star Burn Up?—Ordinarily speaking no star could "burn up," because, while matter may change form, it does not go out of existence. No man not an atheist dares to affirm that matter has always been eternal, but neither does the geologist or astronomer aver that matter ever wholly disappears. In the case of the stars there is no evidence that one has gone wholly out of existence, but some have so changed in their external light and, presumably, internal conditions, as to pass out of human vision. Combustion simply changes structure; atoms are not dissipated to *utter nothingness*. No star, so far as we know,

can burn up and leave a void. Yet to appearances they do burn, or rather they burst out in some immense conflagration which is visible, flash out a beacon light across the wilderness of space, and then disappear from sight.

The most remarkable case on record was a star of 1572, while three of the most notable recent ones were of 1866, 1876 and 1901. That of 1572 was observed by Tycho Brahé (1546-1600). He saw it late in the evening of Nov. 11, when he found the country people gazing at it as he returned home from his laboratory. It was then as bright as Jupiter, and he was sure it had not appeared there with such noticeable brightness one hour before. It seemed to be of instantaneous creation. It grew in a few days to be a rival of Venus, and then larger and brighter than Sirius. For three weeks it so shone, and was visible even at noonday. Then it gradually decreased, and in about fourteen months (March, 1574) totally disappeared. "As it increased in size, it varied in color; at first its light was white and extremely bright; it then became yellowish; afterwards of a ruddy color like Mars; and finished with a pale livid white, resembling the color of Saturn." It was in the constellation of Cassiopeia, and it was thought to have disappeared forever. But astronomers now believe they have established its identity as a very faint star "still smouldering in the spot where it once blazed." If so, it still varies occasionally by one magnitude, but it frequently seems to be nebulous.

The star of 1866 was noticed both in Europe

and America on May 12, and was of the second magnitude, having probably increased five magnitudes in a few hours. In twelve days more it had dwindled to the eighth magnitude. The 1876 star was first noted at Athens, Greece, on Nov. 21, and was of the third magnitude. It rapidly declined, and on December 15 was of the seventh magnitude. Reversing the usual order, this star began as a golden yellow in color, then turned white and finally bluish. Its spectrum was at first like other stars, and then became like that of a planetary nebula. Ten years after it was first seen it was of the fourteenth magnitude.

Of the 1901 star, Professor Young of Princeton gives this description:* "The most recent instance of a new star, and one of the most remarkable, is that of the star which first appeared, probably on Feb. 20, 1901, but was first seen on the 21st, having then about the brightness of the Pole-star. Photographs of the region containing the star, taken at the Harvard College observatory on general dates previous and up to the 19th, show that on the 19th the star had not yet appeared, or at least had not reached a magnitude above the twelfth. It increased in brightness at least 25,000-fold within three days, and on the 22nd it was for a few hours the brightest star in the heavens, Sirius alone excepted, having attained very nearly the zero magnitude—the most brilliant Nova since Kepler's star of 1604. Its rise was extremely rapid,

**Manual of Astronomy*, p. 526.

and its descent was also swift as compared with that of Kepler's star, for it faded rapidly, so that by the end of March it was scarcely visible to the eye." Subsequent observations with the telescope showed that the star is of the nebulous variety, and Professor Young puts its distance as much farther than the nearer stars, and states that its real diameter "must be at least 1,500 times the diameter of the earth's orbit!" Another astronomer thinks the star is 300 light-years away from us.

The dates of other important "new" stars in recent years are, 1891, 1893, 1895 and 1898, only the first of which was visible to the naked eye; they all appeared on photographic plates. Their frequency, since the art of photography as applied to the heavens has come into such common use, proves the instances of such stars are not at all rare.

Other similar sudden appearances and disappearances of stars have been recorded, beginning with 134 B. C., so that there are at least twenty-five well authenticated instances of such temporary stars down to the end of 1901. But it is not supposed by astronomers that all these stars are lost to telescopic view, much less that their light has been totally extinguished. Ten of the instances occurred before the day of telescopes, and the want of accurate star charts may furnish the reason for our inability now to find some of the others. The only thing proven by these phenomena is that the stars do suddenly increase in lustre a hundred or a thousand-fold, and then relapse

to their original condition, which may have been with a brightness too feeble to be seen.

Various causes for such unusual spectacles have been assigned, but all are guesses. Some hold that these temporary stars are stars which have collided with some other large star, (as Professor Bickerson in *Knowledge and Science*, Nov., 1904) or with some huge comet, and that the increased heat thus engendered caused the sudden illumination. Some suppose that certain of these temporary stars encounter nebulous revolving masses of gaseous matter. Some think that they are simply long-period, variable stars. Others (Mr. Proctor among them) hold that the increasing light may be due to the contact of such a star with an enormous stream of meteoric bodies, the light diminishing after the meteoric stream has passed by. Be the cause what it may, these stars for the time being have had their light and heat so increased that they have seemed to be "suns in flames." It can hardly be believed that these new stars are really new creations. The natural development of a star from a nebula (supposing it to be so produced), is more gradual than anything seen in a temporary star, and then it would not "go out." The point of condensation of a star so formed would have first brightened and brightened as it contracted to a nucleus, and this would occupy ages of time. All stars are supposed to act in this way in their normal condition; that is, slowly—during millions of years—carrying on a contraction and continued combustion from youth to old age; then becoming dimmer and dimmer, and

eventually—but at a period almost too remote to calculate—becoming surface-cold.

Colored Suns.—The different conditions under which through the lapse of ages a star finds itself is probably the usual solution of their varying colors. These colors are certainly not apparent merely, but actual. Colored suns! We scarcely realize how diverse are the colors of the stars, even as seen with the naked eye. Generally speaking, they look to be lemon-yellow; but some are readily seen to be ruddy, others bluish, others white, and still others orange. Good eyes will see these differences, and will notice that Arcturus is red, Capella yellow, Castor green, Sirius white, etc. Through the telescope such colors are still more numerous and decided, and are of all shades; and these widely divergent hues are most strongly noticeable in the double stars by contrast. In double stars, which to the eye appear of a fixed single color, the telescope may show two stars, one white or yellow and another green; or one like gold and another lilac; or one red and another blue; and there are faun, mauve, russet, purple and olive stars.

Do these colors appear because of the different vapors surrounding each star, much as white light seen through colored glass appears to be white, green, red, and so on, according to the color of the medium through which the light passes? Railway signals furnish an example of this. Is the real light of a star always white, or yellow, but changed to our view by the external envelope of the star? The general conclusion is that this is the

case, and that the constituents of the various real stars (stars fully massed as stars, and not merely in a gaseous condition), being much alike, their real light must be generally uniform, while the enveloping vapors are vastly divergent. The spectroscope shows some stars to have iron, copper, zinc, etc., in their atmosphere of vapors, and others not, and this would appear to prove that the lack or addition of this or that component in their vapors causes the different colors to be visible to us.

These colors must be just as visible, only more distinct and pronounced, to any beings on worlds that revolve around such stars. It is a singular thought that if there are other worlds with sentient beings on them, these beings must see their worlds lighted up by colored suns. The experience to us would be most unique. Take the case of a world ruled by several suns, as suggested in the preceding chapter. There a blue sun may be rising and a red one setting at the same time; or a white sun be setting and a purplish sun rising; or two, three or four different colored suns be above the horizon at one time! What sunrises and what sunsets there must be amid such strange and curious scenes as this! How varied must be the landscape as it reflects the rays of first one colored sun and then another, or a combination of different colored rays! The thought is only one of many that rise up in the mind, and tend to show that it may well be that stranger glories than we have ever dreamed of are to be seen from many distant points in the Visible Universe. Surely amid such phenomena there is an " infinite wealth of beauty

and variety," greater in degree, though not in quality, than the variety we have in the flowers of the field, of which the Master Teacher said: "They toil not, neither do they spin, yet Solomon in all his glory was not arrayed like one of these."

CHAPTER VIII

Names of Constellations and Stars

Early Constellations.—We have already seen in Chapter II. that more than two thousand years before Christ the Chinese were engaged in astronomical observations. As a matter of course the Chinese must have named many of the larger visible stars, or they could not have kept records concerning them. In the most complete work yet printed upon the Constellations,* it is clearly demonstrated that, long before the time of the Greeks, the primitive constellations received their names, and that such names had their origin with the Babylonians.

The idea of most people is that the constellations were really made up originally from supposed likenesses to the figures after which they were named, but a careful examination of the subject shows that in very few cases has this been the rule. The religion of the ancients was one of mythology, and in order to carry out their mythological views, constellations were made up with

**Primitive Constellations*, by Robert Brown, Jr, : London, Williams & Norgate, 1899, 2 vols.

little regard to their actual appearance to meet the wants of this mythology. For example, as Mr. Brown well says: "The Sun hastens across heaven and earth, and rises from and disappears in the earth and sea; he therefore strides, runs, gallops, drives, sails, swims, flies, chases the dawn, the clouds, the moon, the stars, is born, grows up, loves, leaves, rejoins his beloved, shoots the arrow and hurls the spear, is an eye, a wheel, a shield, is wounded, thorn-pricked, poisoned, sick, leprous, blinded, toils, fights, burns, kills his friends and his enemies, dies, and is reborn in endless life. And those phases are but a few, a very few, of his personified activities. Thus, naturally, the Sun is personified and regarded as a Shepherd, a Warrior, an Archer, a Lance-holder, a Hunter, a Giant, a Water-pourer, a Sailor, a Charioteer; or, again, as a Ram, a Goat, a Horse, a Lion, an Eagle, or a Fish." The relations of all these constellations to the Sun, therefore, were more or less arbitrarily fixed and the constellations made up to match!

There are now sixty constellations universally, and eighty-five quite generally, recognized, forty-eight having come down from the Greeks, and the others having been formed by astronomers since 1600, partly to embrace stars not included in the old constellations, and especially to embrace stars near the Southern pole. Some lists give as many as one hundred and nine constellations, but the majority of this additional number are altogether too fanciful to be recognized by any but the most imaginative.

Names of Constellations.—The constellations are usually divided into three classes, the Zodiacal, which are those through which the Sun passes in his annual round; the Northern, which are north of the Zodiacal list; and the Southern.

There is an old English rhyme which thus gives the name of the Zodiacal constellations:

"The Ram, the Bull, the Heavenly Twins,
And next the Crab, the Lion Shines,
The Virgin and the Scales,
The Scorpion, Archer, and He-goat,
The man that bears the watering-pot,
And the Fish with glittering tails."

All these names are sufficiently well understood by anyone.

Their Latin names are the following: Aries, Taurus, Gemini,Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces.

The leading Northern constellations, as given in both Latin and English, are as follows:

Ursa Major.	The Great Bear.
Ursa Minor.	The Little Bear.
Draco.	The Dragon.
Cepheus.	Cepheus.
Boötes.	Boötes.
Corona Borealis.	The Northern Crown.
Hercules.	Hercules.
Lyra.	The Lyre.
Cygnus.	The Swan.
Cassiopeia.	Cassiopeia.
Perseus.	Perseus.
Auriga.	The Charioteer.
Serpentarius.	The Serpent Bearer.

Serpens.	The Serpent.
Sagitta.	The Arrow.
Aquila.	The Eagle.
Delphimus.	The Dolphin.
Equuleus.	The Little Horse.
Pegasus.	The Winged Horse.
Andromeda.	Andromeda.
Triangulum.	The Triangle.
Camelopardalis.	The Cameleopard.
Canes Venatici.	The Hunting Dogs.
Vulpecula et Anser.	The Fox and Goose.
Cor Caroli.	Charles' Heart.

The chief Southern constellations are the following:

Cetus.	The Whale.
Orion.	Orion.
Eridanus.	The River Eridanus.
Lepus.	The Hare.
Canis Major.	The Great Dog.
Canis Minor.	The Little Dog.
Argo Navis.	The Ship Argo.
Hydra.	The Snake.
Crater.	The Cup.
Corvus.	The Crow.
Centaurus.	The Centaur.
Lupus.	The Wolf.
Ara.	The Altar.
Corona Australis.	The Southern Crown.
Piscis Australis.	The Southern Fish.
Monoceros.	The Unicorn.
Columba Noachi.	Noah's Dove.
Crux Australis.	The Southern Cross.

Few people will be able to make out the constellation-figures, without studying them by the aid of a good chart, where all the figures are outlined.

Positions of the Constellations.—In order for a beginner to learn the chief constellations, he will naturally begin with what is the Great Bear, or, rather, the well-known Dipper, the four stars in which, making nearly a square, are in the body of the Bear, while the row of stars, making the handle to the Dipper, forms his tail. The two outside stars of that square are known as the "pointers," and point toward the Polar star. That Pole star is constantly used by mariners and others at night in order to find that point of the compass known as north. The Pole star belongs to the constellation known as the Little Dipper, which is also as readily recognized as the Great Dipper.

On the other side of the pole from the Great Bear is Cassiopeia, or the Lady in the Chair. It is easily to be recognized from its three or four bright stars, which, by including a star less bright, forms either the letter W, or a chair. In ancient mythology Cassiopeia is a queen, who is supposed to be seated in a large chair or throne.

In the Milky Way, east of Cassiopeia, (in the direction considered east by the layman), is Perseus, which can be recognized by a row of conspicuous stars, extending along the Milky Way. Above Perseus rises Auriga, the charioteer.

A regular chart should be consulted to find the other constellations. We only note now that the Pleiades, or "Seven Stars," of which six are us-

ually visible to ordinary eyes, and with which everyone should be familiar, are in Taurus, the Bull.

Names of the Stars.—The brighest stars were all named by the ancients, for example, Sirius, Arcturus, Procyon, Aldebaran, etc., and while many of the stars were undoubtedly named, as at present called, by the Arabs, others received current names long before their time. The twenty brightest stars in the sky, known as first magnitude stars, and given in their order of brightness, are the following:

Sirius, in the constellation, Canis Major.
Canopus, in the constellation, Argo.
Alpha Cantauri, in the constellation, Centaur.
Arcturus, in the constellation, Boötes.
Rigel, in the constellation, Orion.
Capella, in the constellation, Auriga.
Vega, in the constellation, Lyra.
Procyon, in the constellation, Canis Minor.
Betelgeuse, in the constellation, Orion.
Achernar, in the constellation, Eridanus.
Aldebaran, in the constellation, Taurus .
Beta Centauri, in the constellation, Centaur.
Alpha Crucis, in the constellation, Crux.
Antares, in the constellation, Scorpio.
Altair, in the constellation, Aquila.
Spica, in the constellation, Virgo.
Fomalhaut, in the constellation, Piscis Australis.
Beta Crucis, in the constellation, Crux.
Pollux, in the constellation, Gemini.
Regulus, in the constellation, Leo.

The name-meanings of some of these leading stars are as follows: Sirius, from Siris, the Nile; Arcturus, guardian of the bear; Rigel, foot; Capella, a little she-goat; Vega, falling (eagle); Procyon, precursor dog; Aldebaran, the eye of the bull; Altair, the bird; Spica, an ear of wheat; Regulus, chief, etc.

Other prominent stars, not among the twenty named above, are: Algol, the monster; Myra, wonderful; Mizar, a girdle, etc.

Astronomers at present are not using, however, the star names which were formerly in common use, but others, upon a plan designed by the celebrated astronomer Bayer of Augsburg, Germany, about 1610. He made a set of star-maps, in which the individual stars of each constellation were designated, first, by the constellation, and next by the letters of the Greek alphabet. To the brightest star in a constellation the first letter, *alpha,* was given; to the next brightest star, *beta,* and so on. The constellations themselves were given their usual Latin names. If in any case the Greek alphabet was exhausted, the Latin alphabet was next employed. The Bayer system is still used as to all the stars named by him. But as to most of the telescopic stars numbers are used corresponding with the numbers laid down in certain charts, for example, "Lalande, 21,100," "Groombridge, 1830," etc.

CHAPTER IX

The Music of the Spheres

Motion Everywhere.—All the stars move. We know of none within the range of surface-observations in our own Solar System which do not revolve upon their axes, and we know that all stars within range of measurement are rushing forward at great rapidity through a definite orbit. In other words the whole Visible Universe is instinct with life. Life always means motion. In this world, plant life and animal life cannot stand still; they move forward in growth and to some fixed goal. Light, sound and heat follow this general law of motion. The light that we see from a star to-night is not visible to-morrow night, nor even for a thinkable fraction of a second after the present moment; it is hieing on with overwhelming speed toward outermost space. Sound moves forward in waves, on and on, to be lost only on the shores of the far-away. The Sun moves, and the whole Solar System with him, and every star under the skies is moving through the—shall we say infinite?—ether.

This is what, perhaps, we may understand by the sentence in the Bible, that at the creation " the morning stars sang together." This is the " music of the spheres." These millions of orbs and planets make no noise to human ears, but we are not sure that to ears seraphic there may not be a " concourse of sweet sounds " of infinitely sweeter chords than in the grandest production of a Beethoven. If this be wholly imaginary, nevertheless

there is the constant motion and in all conceivable directions, and the thought involved in it is overpoweringly glorious.

This fact alone furnishes reason enough for the mighty distances that divide star from star. There must be room for these great orbs to swing themselves undisturbed by the attractions of other spheres, and by other systems of spheres, and there must be the minimum of chances of collision. We do not really know that any orb has ever crashed into another since man has been upon the Earth, and there are no calculations made that make it probable that in the next million years any one star now rushing on its course through space may come in contact with another. The distances from star to star and system to system are too vast to make the "chance" a likely one in one case out of a billion. There is an immense diversity as to the points toward which the various stars are tending and in their rate of speed, but all seem to be pursuing their course with plenty of space, and, what is of more importance by far, under fixed law and so in absolute safety.

Motion of Our Sun.—Whither is the Solar System going? To what goal is our own Sun hastening? Is it moving around some other central body, whose attractive power is felt, but which is so far away as to be invisible, or perhaps visible, but unknown to us?

It was once soberly announced by Mädler, the German astronomer (1794-1874) that he had computed that the whole stellar Universe, our Sun and system, and all other stars and systems,

were revolving around the star Alcyone in the Pleiades; and for a time it caught the popular mind and was written up in books and articles as a probable fact. But this was soon shown to be a baseless speculation. His so-called "proofs" were not endorsed by any astronomer. "If there be such a visible centre, around which our system moves, it is more likely," says Flammarion, who is the greatest living French astronomical writer, "to be in the constellation Perseus."

It is a difficult matter, indeed, to separate the motions of the stars themselves from the motions of our own system, so as to indicate how much of the apparent motions of those stars are due to such real motions, and how much to the motions of our system. However, the problem has been attacked with assiduity by different astronomers, and it is now generally conceded that we are moving—the Sun and all its planets—away from the constellation Columba, and either toward the constellation Hercules, or to a point between it and the Lyre (the next constellation to Hercules), at a rate not exceeding 18 1-2 miles per second,[9] which means 67,000 miles per hour, 1,600,000 miles per day, and 568,000,000 miles per year. The line of motion is also not believed to be straight, but with so transient a curve that, it has been conjectured, the revolution of the Sun in whatever may be its wonderfully long orbit could not be completed in less than some hundreds of thousands of years, and at least one astronomer has given it the long period of 18,200,000 years.

The motion of the Sun in this orbit is not quite

so swift, however, as the motion of the earth in its smaller orbit, nor equalling that of Venus and Mercury, but it is more than twice as swift as the motion of Jupiter, 28 times as swift as the moon, and 56 times the velocity of a cannon ball, as the following table will show:

The Earth travels in its orbit. 19 miles per second
Venus travels in its orbit. . . . 22 miles per second
Mercury travels in its orbit. . 29 miles per second
Jupiter travels in its orbit. . . . 8 miles per second
The moon travels in its orbit. 2-3 miles per second
The Sun travels in its orbit. . (perhaps)
18 1-2 miles per second

The Motions of Other Stars.—Accurate determination of the exact positions of the stars with reference to one another, so as to furnish a precise basis for measurement, have only been made for a century and a half; therefore, the data for learning their real motions in space are not yet sufficient to make us sure of the figures concerning even the majority of those which have been carefully observed. Something like five thousand stars have been observed carefully within the period of time named, but the published results of different astronomers usually disagree. It must be remembered that the merest fraction of the second of a degree in the heavens at a distance of trillions of miles makes a vast difference in all such calculations, and star-charts, without the art of photography, can scarcely be considered absolutely accurate. Such charts have been made on a great scale, however, so that now, as has been stated, the positions of some 600,000 stars are charted. Pho-

tography has recently come to the aid of the chart-makers, and is noting positions with an accuracy which is unassailable. A hundred years from now the use of these photographic charts will make the calculation of the motions of the stars far less difficult than heretofore.

By the naked-eye it is doubtful if as many as twenty stars visible in the heavens in the days of Job have so altered their positions that such alterations would be noticeable to that lay-astronomer were he now to visit the earth. No star has moved in one century to the extent of one-sixtieth of the apparent width of the full moon, with possibly two exceptions, one of which is Arcturus, which has probably moved several diameters of the moon in 3,000 years. The vast majority have not shifted one-tenth so much. Of the swift flyers in the Universe, some eighty have been calculated as making unusual speed, although their distance away makes this speed not cognizable to the naked eye for centuries.

While it is difficult for the reasons suggested to ascertain the real velocity of a star through space, until a sufficient time has elapsed for photographic observations many years apart to be compared, yet the apparent rate of speed at which stars are approaching or receding from the earth can be closely and immediately approximated by the tell-tale spectrum, which gives these figures with marked fidelity. It is true that even then there are causes operating to give slight variations in the spectrum at different observations, but there is at least never a mistake as to whether the star is *ap-*

proaching or *receding* from the earth, and usually the degree of motion can be carefully computed.

In the spectrum the position of a ray depends solely on the wave length of the light. The longer light-waves are of red, orange and yellow colors, and it has been marvelously calculated that the red light waves number 422,000,000,000,000 in one second of time; the shorter light-waves are the green, indigo and violet, the violet being most numerous, or numbering 702,000,000,000,000 in one second of time. The shorter light-waves converge toward one end of the spectrum and the longer ones towards the other. Now it is proven that the rapidity of progress of these trillions of light-waves is equal, but they differ in numbers per second. Also that waves of light of an approaching body are shorter in the spectrum than if the body be stationery. They " gain," so to speak, upon the point where the observer is. When receding, they are longer; they " lose " upon the observer. So, when the light-waves of a receding star come into the spectroscope, the colors of the one class shift together toward their proper end of the spectrum, and if of an approaching star they are perceptibly crowded toward the proper end of that class. As one or the other class crowds together toward one end of the spectrum the story of the star's motion is told as no telescope can tell it.

The fact that a star is moving toward or from the Earth at a certain rate per second only proves its velocity of motion in the line of sight, and not its actual motion in its orbit. To secure the lat-

ter, observations by the telescope are of course necessary, and both telescopic and spectrum results must be considered to ascertain the real motion.

One of the most interesting features connected with the motions of the stars is their unity, or want of unity, of motion in their particular star-groups. Suppose, for instance, that we are considering the motions of the bright stars in the Pleiades. Should they all be moving toward or from us, and also in a certain orbital direction, the conclusion is then almost irresistible that they belong to one system controlled by one gravital force and are not isolated stars, moving in varying directions athwart the heavens. Their actual rate of orbital speed may be immaterial, but it makes a great deal of difference as to whether or not they move as one associated group. Now, it has been found that such is the case with that group of stars. Not only do the leading stars of the Pleiades move together, and with such exactness that it has been impossible as yet to determine any difference in their proper motions, but it is also true of the larger number of the fainter accompanying stars of the Pleiades seen only in the telescope. Should it be found that all the more than 2,000 stars of the Pleiades belong to one tremendous system of suns, the thought of the glory of that system as compared with ours is overwhelming. In this same connection it is interesting to observe that if our own Sun should be visible from the Pleiades, which is quite certainly impossible (except by a telescope), it would probably not be seen to be moving in the identical direction of

many other stars with which it might seem to be contiguous; although some astronomers believe it practically belongs to a group of 400 suns in a certain part of the Milky Way.

The same thing is the case with five of the seven bright stars of The Dipper, and with scores of other associated stars in certain parts of different constellations, if not in whole constellations themselves. They do move in groups as by a common impulse.

The average motion of the chief stars, as shown by the spectrum, i. e., in the line of sight, seems to be about 30 miles per second. Vega is approaching at about the rate of 47 miles per second, and Procyon is receding at the same rate, but other stars range from 10 to 20 miles per second. The real motions of nearly all the stars, however, are much greater, the Sun's being only two-thirds the general average. It should seem to us that the full rate of the Sun's speed of 18 miles per second is not slow traveling, but it is slower than that of hundreds of other stars whose approximate motions are known. In the line of sight alone, Sirius was at one time receding from us at a rate exceeding 20 miles per second, and then approaching at a similar speed, showing that he had made a turn in his mighty orbit. Polaris, the north Polar star, is approaching at the rate of 16 miles per second, but is so distant that its light takes 50 years to reach us. Arcturus is supposed to be approaching us at the rate of 55 miles per second, an unusual rate of approach, but then Arcturus is the swiftest known body in the Universe, being exed-

ited with journeying at the unprecedented pace of 372 miles per second across the line of sight alone! Formerly the swiftest known star was that called "The Runaway Star," or 1830 Groombridge, whose actual velocity is estimated at 200 miles per second, or 720,000 miles per hour, which, says Prof. Newcomb, is "a speed uncontrollable by the combined attractive power of the entire sidereal Universe." It would look almost as if Arcturus and 1830 Groombridge were exceptions to other stars and were running a wild race toward the infinitudes, but we have no doubt that some unknown law holds them to a definite, though incalculable, orbit. On the whole no star is believed to be at rest, and it cannot be imagined that any one of them could be at rest under the laws of gravitation which control the Visible Universe.

As to the periods of the revolutions of the stars in their orbits, it has been supposed that 1830 Groombridge might require 185,000 years to complete the circuit of the heavens, and a swift one in Cassiopeia, 340,000 years; and that stars of the fourth, fifth and sixth magnitudes (to which our Sun evidently belongs) would not make one full revolution in their orbit under several millions of years.

CHAPTER X

Everywhere Life and Death

Nebulous Matter.—"Nebulæ" is the name *given to* those faint patches of light which are

seen here and there in the sky, chiefly, but by no means exclusively, in the Milky Way. Many masses of seeming nebulæ are resolvable, in whole or in part, into stars under the telescope, or by telescopic photography, but others are totally irresolvable, and are known by their spectra to be gaseous. The best defined one which the naked eye can see is in Andromeda, and it is sometimes called the "Queen of the Nebulæ," because it has always been a beautiful and conspicuous object in the telescope. The ancients probably knew of it, but do not mention it. We hear of it, historically, first in 905, when the Persian astronomer Al-Sufi speaks of it as a conspicuous object. Halley said it was "nothing else but the light coming from an extraordinary great space in the ether, through which a lucid medium is diffused that shines with its own proper lustre." Photographs taken in 1888 showed that it was composed of concentric nebulous rings, and went a long way to give stability to the theory of Laplace that the various bodies of our Solar System (and suns and worlds in other systems) have been evolved from rings detaching themselves from a rotating nebulous mass. The spectroscope, however, shows this nebula in Andromeda is not now strictly gaseous, but has gone beyond that state. The breadth of this nebula is conjectured to be 333,000 times the Sun's distance from the Earth. If this be true, it would require over five years for light to cross from one side of the nebula to the other.

Another beautiful naked-eye nebula is in the sword of Orion. This is more cloudlike, and the

spectrum shows it is gaseous. So far as we know, this nebula was not observed until 1618, and it is believed to be undergoing changes with more visible rapidity than is the case with most similar classes of nebulæ.

Different Kinds of Nebulae.—Many people speak of nebulæ as if they were all of a kind; not necessarily alike in size or shape, but of a uniform brightness, such as all gaseous matter with which we are acquainted generally appears when luminous. But this is to convey a wrong impression of these "bright patches of the skies." Generally speaking, they are of one hue, but here and there portions of a certain nebula have greater lucidity (or brightness) than others. Uniformity of light throughout a nebula is not the rule, and there are also certain decided points of condensed brightness. They are also of various and often curious shapes; in fact, so much so that these have been classified into nine different classes:

1. Nebulous stars, i. e., stars with a nebula surrounding them. There is such a star in the constellation Taurus, which is a perfect star, and yet is enveloped in a close-fitting nebula. It is this which led Sir William Herschel to the conclusion that there existed in space "a shining fluid of a nature totally unknown to us." No one now believes there is anything like a "fluid" (except ether) filling space, and it is not self-luminous. No one questions that there is a medium known as ether, which must exist for the purpose of conducting light-waves. This nebula in Taurus is *more, however,* than the bright envelope of the

star, like the solar corona, or the illuminated so-called Sun's atmosphere. It is too extended to be anything like this, as it fills a space around the star 27,000 times as large as the whole orbit of Neptune. Its irregularities of light also indicate that it is still in the midst of its "unfolding activities." In Herschel's day thirteen nebulous stars were known, and the number has since been largely increased by other observers.

2. Planetary nebulæ. Such shine not with the usual faint yellow, but with a bluish light, which is associated with planetary (reflected) light. In them the centre is well-defined, yet is not a bright star, and the light away from this centre is usually very uniform. The name originated from the fact that it was formerly supposed that the central point presented a real disc, such as a planet will present, but not a sun, but this is now found not to be true. About 70 such nebulæ have been charted, in some of which the centre light has the appearance of two or more superimposed discs, as if it were about to become two or more stars. Some of them seem to be tending toward the annular and spiral nebulæ.

3. Annular nebulæ. They consist of an oval, bright ring, the interior of which is filled with a nebulous haze " like gauze stretched over a hoop," and sometimes a great number of faint stars appear without and within the ring. The ring is usually elliptical and not a perfect circle. In one such nebula a central star once visible seems to have totally disappeared.

4. Spiral nebulæ. They consist of a system of

bands, circular, or semi-circular, and may be likened to wreaths, but are not connected at the end; or sometimes appear as a "large spiral, full of knots;" or are spiral chiefly in the sense of having a rotating or whirling motion. The frontispiece in "How the World Was Made"* shows the latter kind of spiral nebulæ in Virgo, which probably represents the form of nebulæ that is usually associated with the beginnings of a whirling motion in as clear a manner as any other. When a nebula groups itself in curved lines—and those lines may really constitute various specific shapes with curved lines for a basis—it is called a spiral nebula.

5, 6, 7, 8, 9. We have also cometary nebulæ, in appearance much like a comet; double nebulæ; elliptical nebulæ; dumbbell nebulæ, and irregular nebulæ. The name of each implies its appearance and we need not say more about them.

The present number of known nebulæ which can be seen in the largest telescope is probably 10,000, but photographs of the heavens after long exposure indicate that there are hundreds of thousands of nebulæ, and sometimes the suggestion is made that the whole Visible and Invisible Universe may be full of nebulous gases, the most of which are unilluminated. It is believed that all of the visible nebulæ, except forty, are more than ten times farther away than the nearest of the stars, and that the faintest are, probably, on an average, one hundred times as far away.

*In this "Library," No. 4.

The Nature of Nebulae.—The word nebula means "cloudlike," and the name is based upon its appearance. That its substance is chiefly gaseous, containing enormous masses of hydrogen, is proven by its nearly continuous spectrum. There is, however, one chief line in the spectrum of nebulæ, indicating a substance not yet known to the earth, to which the name has been given of nebulium, for want of any better designation. None of the spectra of nebulæ show the presence of those separate elements of matter which go to make up a star, or even our Sun, and this fact must be taken to indicate that, whatever matter is in the nebulæ, it is in an almost infinitesimally diffused state. Another reason for this belief is that, as a rule, all nebulæ are transparent, stars being seen through them, with no apparent diminution of light, from which fact it has been calculated by Mr. Ranyard that their density must be about the one ten-thousand millionth part of the density of the Earth's atmosphere at sea level. Nor is it to be supposed that this gaseous matter is in a state of combustion, as we understand that word to mean. Combustion must soon change physical conditions, but nebulæ have not changed appearances to any astonishing degree since the invention of the larger telescopes. It is supposed that the nebula in Andromeda has somewhat altered in the past century, but to what extent is not clear. If the other theory be adopted, that electricity, steady and continuous, at least so appearing at the immense distance at which we view it, plays a part in the illumination of these primeval

groups of gaseous matter, some of the difficulties disappear. The command, "Let there be light," may not have been applied to the illumination of any nebulous mass just as we now see it, but at the present time science is in no condition to antagonize religious faith as to primeval beginnings.

It also seems to be probable that the "newest and youngest" nebulæ (if we may use such terms) are stable, and not in revolution, but the most of them, like the stars, are either receding from or approaching us. How, in process of time, through condensation and clarification, if not before begun, rotation begins, seems to present no difficulties to scientists, since they understand that gravity of itself has sufficient force in it to start and to continue the machinery in rotary operation.

Some astronomers suppose nebulæ to be very like the heads of comets, though more diffused, but this remains to be verified. We know extremely little about the heads of comets, except that they are gaseous in nature and glow in brightness as they near the Sun, and diminish as they recede from it; whether their light be inherent or reflected is still in debate. We do know this, that comets leave in their trains streams of detached meteors, which may or may not come from their heads, and may or may not be among the components, or characteristics, of nebulæ; although the nebula in Andromeda does have very much the appearance of swarms of meteors. Our Earth has never yet run into a nebula, as it has into these wanderers in a comet's path, and so we do not

know whether meteors are bound up with the elements in nebula construction, or not.

In any event, nebulæ may be considered as bases for the building of future suns and worlds, and, if so, in them we see as far back toward the beginning of Creation as we can possibly see with eyes and telescope while we remain inhabitants of our present planet. Supposing them to be the foundation of all primitive sidereal life, we can go no farther.

Life in Other Worlds.—We have seen that it is not too much to assume that there are other definite systems of stars in the Visible Universe besides our own little solar system, and it is no irrational assumption to say that there are probably millions of planets, some of which must be in the condition of our own, as to climates and capacity for supporting life. It would be, indeed, most strange if it were not so. That there should be one hundred millions or more of suns, and no planetary worlds save one, (and such a tiny one!) seems incredible. We know that many, especially religious people, who are not astronomers, shrink from the thought that the entire collection of intelligent beings in the whole Universe is not that known as the Race of Man, for whom Revelation tells us the Creator has done so much. But is it not belittling to the Almighty to imagine that He has exhausted His creative energy in making this one world, and putting intelligences on this one little planet; or that He has purposely avoided placing living beings on other worlds, perhaps lest the sad experience of a "race fallen from upright-

ness" might be repeated elsewhere? We know little of His purposes; then why limit them by our creed or religion, or our imperfect concept of either the Divine power or Divine will?

The doctrine of a "plurality of worlds," where life may exist, is a comparatively modern one, but fits in with science and the highest outsweep of human thought. It is a doctrine full of possibilities, even from a religious point of view. Everything, in other portions of the Universe, is arranged for planetary existence, if not precisely in the condition of the Earth, yet under circumstances often far more glorious. Larger suns, colored suns, groups of suns, myriads of suns, may have been created for no other purpose than to give their feeble light to our Earth, but no rational man ought to suppose such a thing for an instant. It is too great an outlay of energy for so trifling a result. The creation of one more moon, one-quarter the size of our present moon, would give to us all the additional light at night that is furnished by all the stars.

Again, our place as men and women may be the highest place in the Universal Creation, but, if so, we ought to be appalled at the immense gap between the savages of Africa and the angels, who are supposed to gather around the throne of the Eternal. It cannot be wholly imagination to suppose that there are intelligences, in nature at least equal to, possibly immeasurably above, our own, making other portions of the Universe musical with the better harmonies of better conduct, and *with songs* of purer praise. Otherwise, why all

this array of stars, and these evident specimens of star-building and world-production?

We cannot see other planets, but that furnishes no reason to suppose that they do not exist. If we could be located this moment near Sirius, we should never suspect that our own Sun had even one, much less eight, chief bright planets circling round him, or that there was anywhere in this Solar System a single human being. The fact that we cannot prove that there are intelligences on Mars, or on Venus, or that it is not reasonably certain that they are there, does not give weight to any doubt as to the Universe having many worlds similar to our planets, or that some of these worlds, being fitted for the abode of life, do have life upon them in all its vegetable and animal varieties. We have seen, in a previous volume in this "Library,"* that Man came upon the Earth just when it was prepared for him, and not an age earlier or later. After millions of years, of slow but gradual preparation, "the clock struck twelve" for Man to appear, and he came. So it is likely with the neighboring planets of our own system, although only one of them at the present time, in all probability, has arrived at, or is approaching, the stage when plant and animal, and especially human, life can exist. On Jupiter and Saturn, Uranus and Neptune, Time will yet produce the conditions, and then, it is rational to believe, will appear the lower, to be succeeded by the higher, forms of Life.

**How the World Was Made.*

So in other systems. Perhaps only one planet in a system, perhaps only one planet in many systems, is exactly ready for such creatures as shall have the soul-intelligence of Man, but, even so, amid the multitude of systems, the number may be very great; and, even if not so, who shall say that wholly different soul-intelligences may not live under very different planetary conditions from that of the Earth on other planets! The assumption that the conditions of life are the same in other worlds as in our own is a natural one, but is not a proved one. It is one, indeed, which sets a limit to the Divine power.

Conceding, also, for the sake of logic, that no planet, whatever its geological condition, could sustain life unless its central orb, its sun, were of similar constitution to our own Sun (and, if our Sun were much different from what it is, neither vegetable nor animal life, much less human life, could be supported on the Earth), then we may, by mere mathematics, figure out the probabilities of the number of inhabited planetary worlds in somewhat the same manner Mr. Gore (a living English astronomer of much learning) has done, and this will be the result: "The number of stars visible in our largest telescope is usually estimated at 100,000,000. Of these we may, perhaps, assume that 10,000,000 have a spectrum of the solar type, and therefore closely resemble our Sun in their chemical constitution. If we suppose that only one out of ten of these is similar in size to the Sun, and has a habitable planet around it, we *have* a total of 1,000,000 worlds in the Visible

Universe, fitted for the support of animal life." Certainly this is but guesswork, yet it contains abundant food for thought and wide-reaching speculation.

Chances of Collisions of Stars.—Are there chances that the stars, which move in so many directions with such tremendous speed, and which have no calculable orbits, may sometimes collide with each other? May our Sun ever crash into another sun, or even our Earth with a stray planet? Is this to be the manner of a sun's or a planet's death? We are not prepared to admit that under the known laws controlling the Universe such can be the case, at least so far as actual orbital motions are concerned. The Creator has given plenty of room to every star and system; they are not as blindfold knights, going any whither into battle, but move with the precision of pre-determined accuracy. No human-made clock is as accurate as the siderial time-pieces. The exactness with which the moon keeps her place in the heavens, century after century, and the corresponding adjustment of these planets to each other and to the Sun, argues that, for at least some æons, there will be no collisions. In any event there will come no collisions by chance, as the laws of the Universe do not permit of chance. It may be difficult to understand how any law can eliminate chance to the uttermost infinity of a fraction, but God's laws are not human laws; they are perfect, whereas ours are far from it.

Deaths to Suns and Worlds.—All material things change. Nothing is stable save that which

is of the essence of the Eternal. Matter is in form, if not in fact, far from eternal. It changes somehow, somewhere, by every tick of the great clock of years. The globe is not the same on its surface as it was a hundred years ago, and the most recent discoveries show that its atoms are undergoing constant molecular changes. Water, ice, fire and a variety of processes also devour, or otherwise alter, the positions and substances of matter. Generally speaking, all things are hastening, or tending, toward *Death.*

It may be soon, it may be remote, probably it will be very remote, but some day we are sure that Death will overtake the human race, just as it now does individuals of each generation. The race may disappear, sometime, as suddenly as it was born. The reason why the race must die is not that it is Scripturally forecasted—which, of course, has no weight *as such* with the scientists—but because, in this one matter, as in so many others, Revelation and the highest deductions of science are one.

Climate is slowly changing and will continue to change. Science declares the Ice Age may return, and that, in any event, the world will eventually lose its atmosphere and all the conditions that now support life; that one day it will become as our moon—a cold and lifeless world; that it will not longer revolve on its axis every day, but, like the moon, point the same face toward the pitiless Sun century after century.

The Earth has been losing heat ever since it was first a burning, or illuminated, mass of chemical

and mineral consistence. Of necessity this is so. Had it not done so, it would never have been what it now is. This loss of heat must go on to the end of it, unless some mysterious outside agency intervenes to keep the heat up forever; and we know of nothing in the forms of generated matter which will engender and re-engender heat throughout all eternity. Heat is only supplied through the expenditure of some force, and the supply of material force is limited by the extent of the material itself. This is a truth that is axiomatic. Perpetual motion, perpetual life, perpetual heat, perpetual energy of any kind, is unknown to this world, and, by analogy, is unknown to the systems of all material worlds. Every result is from a cause, and every material cause in time comes to a period of cessation, which is *rest.*

One of the interesting features of the generally accepted theory that the earth, sun and stars will one day be " blotted out " is, that the human race has always believed in the end as well as the beginning of created things, although they have also held that new creations would follow. The Chaldeans averred that the world comes to an end once in about 25,000 years, and the system is then reorganized. The Egyptians gave to it a longer cycle of duration; it is not clear whether the extent of it was 120,000, or 300,000, or 360,000 years. The Hindoos gave the world a duration of 4,320,000,000 years, when it would be destroyed by fire. The Babylonians divided that number by ten, and the Chinese said 104,181 years. The Jews believed in a prophecy that the world would last only 6,000

years, 2,000 years to the Flood, 2,000 years to a Messiah, and 2,000 years to the end of all things. All the oriental nations held to a destruction of created matter in some future era. Cicero said that 'the memory of mighty deeds could not be eternal, since conflagrations and deluges periodically obliterated all record of human achievement.' Even the American Aztecs had their cycle of time, in which the world and the Sun itself would be destroyed.*

The Sun is cooling off. Its tremendous energies are, apparently, still young, but its replenishment from its own stores within must cease; and if there are slight replenishments from without, as from the impact of meteoric stones, that, too, cannot go on everlastingly. Astronomers are genally agreed that, for the present, the constant contraction of the Sun in its efforts toward condensation and solidification is sufficient to keep up its heat to its normal extent. A contraction of 250 feet per year in its diameter will be sufficient to do this. But it cannot contract for an eternity of time; eventually it must become a solid. Professor Newcomb, a most careful writer in his statements, thinks that the Sun could give sufficient heat to afford life on the Earth for 10,000,000 years; then it would reach the point of coldness, when life could no more exist.† Professor Young, of Princeton, than whom we have had no more able student upon the composition and ac-

*See *The Aztecs*, of this "Library", p. 64.

†*Popular Astronomy*, by Simon Newcomb, fifth ed. p. 520.

tivities of the Sun, gives it as his conclusion that "the total life of the solar system, from its birth to its death, is included in some such space of time as 30,000,000 years."*

When life departs from the Earth and it becomes a dead planet; when the Sun cools off completely; when the same event, by the identical and inexorable laws of Nature, occurs in all systems, what? Of what future use will be this vast array of matter? Will there everywhere be a cessation of motion, and each system, one by one, as it reaches its "grave of enormous years," come together through the forces of gravitation in one general aggregation of cold and inert masses? This is to go too far beyond our mental ken. God knows; we do not. Such things are too deep for us, just as the heavens themselves are too high for us.

A Comforting Thought.—But, in the meantime, there is this thought to comfort us who are living in the present, that so far as we are concerned, there is

> "One God, one law, one element,
> And one far-off Divine event
> To which the whole Creation moves."

For us the machinery of the heavens is in perfect running order, and will not run down for many and many an æon. The Cycle of Matter, as it is now in progress, will continue so long into the future that we need not worry over its forces culminating in any local or general catastrophe in

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*_The Sun_, by C. A. Young, second ed., p. 277.

our generation, unless by the direct interposition of the will of the Divine Mechanic. And, lastly, the mind of Man, which has proven in so many ways that it can triumph over matter, contains as its very essence a spark from that enkindling Spirit, Who has made and watched over this whole Creation until now, and will until its end, and by Whose power and free consent the Soul has been made and is to be truly eternal. When all created things within our ken have perished and "the heavens shall be rolled together as a scroll,"* Man, the immortal, will only have begun to burn his inextinguishable lamp of Light.

NOTES ON THE TEXT.

[1]Page 6. Planet means "wanderer;" the planets seem to "wander" among the other stars, which appear to remain stable.

[2]Page 23. Hipparchus has been well called the "Father of Astronomy." He not only catalogued the stars, but solved plane and spherical triangles, devised the lines of latitude and longitude, discovered the Precession of the Equinoxes, calculated eclipses, divided the day into periods of twelve hours each, and determined the periods of the planets.

[3]Page 24. It has been stated that Jansen, of Middleburg, Holland, a few months prior to the time when Lippershey applied for his patent, had constructed a telescope sixteen inches in length, but was prevented from using it by a large bribe

*Isaiah 34:4.

from two members of the royal family. It was Lippershey, however, who made it known, and his application for a patent (1608) got to the ears of Galileo.

[4]Page 33. Notwithstanding that Sirius is the brightest of all the stars, its actual light would have to be multiplied to our sight 7,000,000,000 times before such light would be as bright as our Sun.

[5]Page 38. It is not capable of demonstration that the Sun is in the centre, or near the centre, of the Milky Way, but all observations point toward such a conclusion.

[6]Page 41. Dr. Gould figures out that the stars of all (apparent) magnitudes, if they were of an equal number in each magnitude, should be such that the great Lick telescope should show 11,830,-114,720 stars. We know this is not the case, and that only about 100,000,000 are visible.

[7]Page 45. No one knows how cold the ether in space is, but assuming that it is not heated at all by the emanations of heat from the suns (or stars) and nebulæ—which is a mere assumption —it must be at the absolute zero of temperature, which is believed to be—459.4° Fahrenheit, i. e., 459.4° below our ordinary Fahrenheit zero.

[8]Page 46. Precession of the Equinoxes. The North Pole of the Earth is supposed to point steadily toward the North Star, but there is an unsteady motion of the axis of the earth as in the action of a spinning top. As a result the true North Pole describes a little circle in the heavens in the course of about 25,695 years. This fact

was known by Hipparchus, but it was Newton who first discovered that it was the combined result of the motion of the Earth and the attraction of the sun and moon, such attraction acting unequally because the Earth is not a perfect sphere. We speak of the Precession of the Equinoxes because each year by means of the foregoing stated fact, the spring equinox is about twenty minutes earlier than the year before, so that in the course of 12,848 years the vernal equinox will be in the present position of the autumnal equinox.

[9]Page 74. Some astronomers have computed the Sun's motion in space at 14 miles per second. Dr. Krupf, of Potsdam, fixed it at 11.5 miles. A more recent calculation (1902) makes it 19.8 miles. The exact velocity cannot be considered as settled; it is one of those problems that, for various reasons, is a most difficult one to solve.

POPULAR WORKS IN ENGLISH ON THE STARS.

Ball, Sir Robert. "Story of the Heavens." London and New York, 1900.

Clerke, Agnes M. "Astronomy." (Concise Knowledge Library). New York, 1898.

Flammarion. "Wonders of the Heavens." New York.

Flammarion and Gore. "Popular Astronomy." New York, Appleton & Bro.

Gore, J. Ellard. "Visible Universe." London, 1893.

Irving, Edward. "How to Know the Starry Heavens." New York, 1905.

Lockyer, J. Norman. "The Dawn of Astronomy." New York, 1897.

Newcomb, Simon. "Popular Astronomy." New York.

Proctor, Robert A. "Myths and Marvels of Astronomy," "Other Worlds than Ours," "The Flowers of the Sky," "The Expanse of Heaven," "Our Place Among the Infinites," etc. New York.

Young, Charles A. "Manual of Astronomy." New York, 1902.

(There are many others, of the same character as the above, in any good public library).

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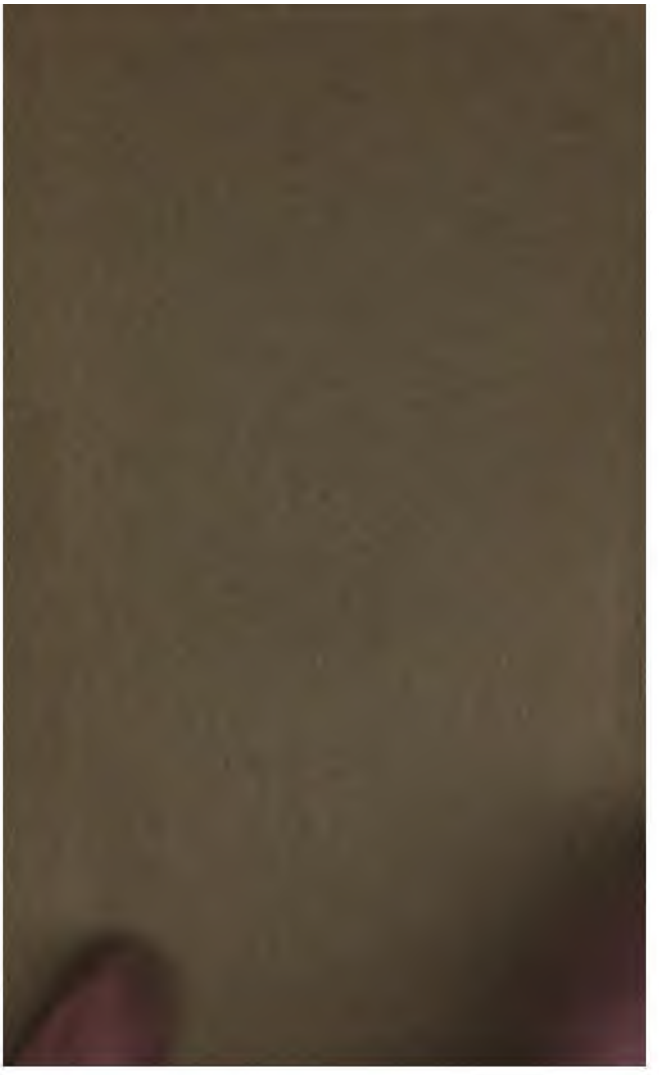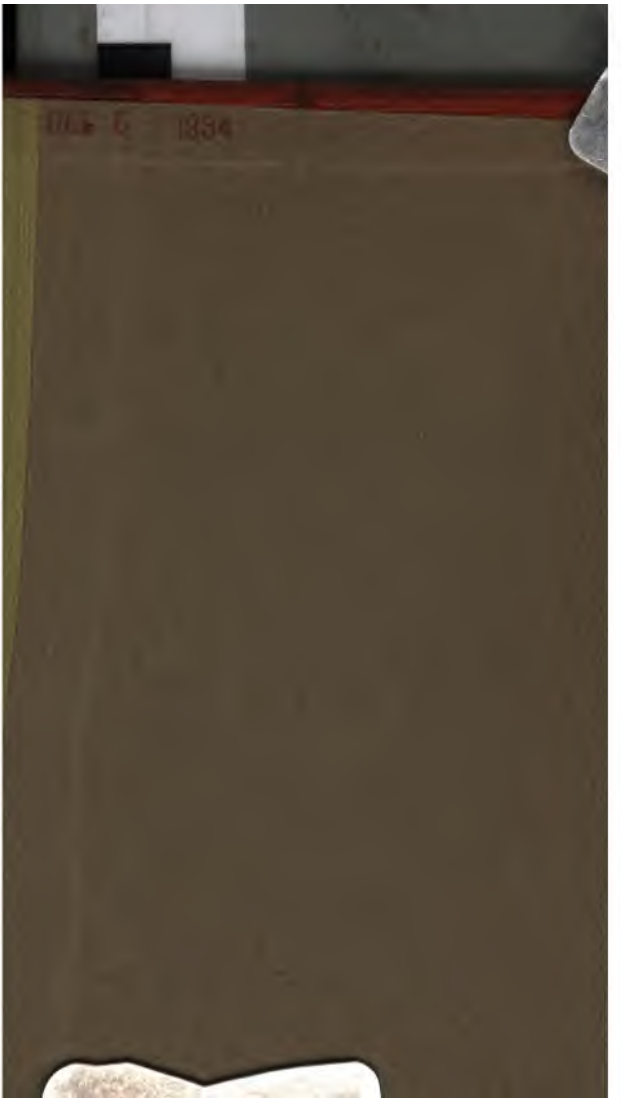
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